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REPRODUCTION IN FRESH-WATER ALGÆ.

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AMONG the higher forms of vegetable life, two distinct methods of reproduction have long been observed, namely, by means of seeds and through some outgrowth from the parent plant. The first method is styled the sexual form, because there is involved in the production of a seed the male element, represented by the pollen grain, and the female part called the embryonal vesicle. In fact, it is the blending of the contents of two separate and distinct cells to form a germ, which under favorable circumstances is capable of producing a plant like the one from which it came. Under the second method fall all those forms of continuing the species other than by means of seeds, which are very common in nature and extensively practiced in the art of horticulture. In essence this is nothing more than multiplication by offshoots or by removal of parts of plants, which when naturally or artificially separated will continue to live and grow.

Let us pass by the interesting and more familiar field of sexual and asexual reproduction among Phænogams, and spend a few moments in looking at these same methods as shown to us by the Algæ of our fresh-water ponds and streams.

When we have a plant consisting of a single cell, and in the process of time the walls of that cell close in and divide it into two separate and similar cells, each of which soon attains the normal size and divides again in the same manner, we have the clearest illustration of asexual reproduction. The lowest forms of fresh-water Algæ furnish thousands of such examples, where the offshoot and parent plant are not distinguishable because equal in all respects; and in which division of cells results in the multiplication of individuals in the ratio of one to two, as shown in Figure 85, *a*. In other cases the division is not so simple, for, instead of each dividing into two cells, a single unicellular in-

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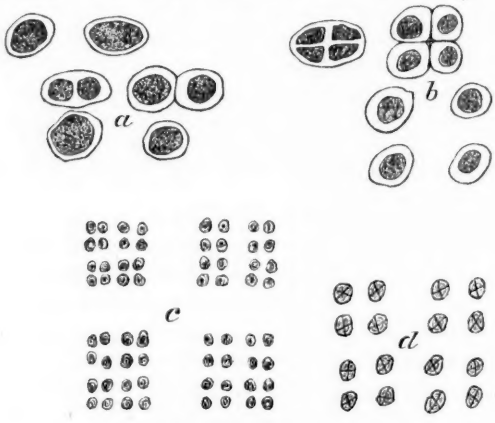
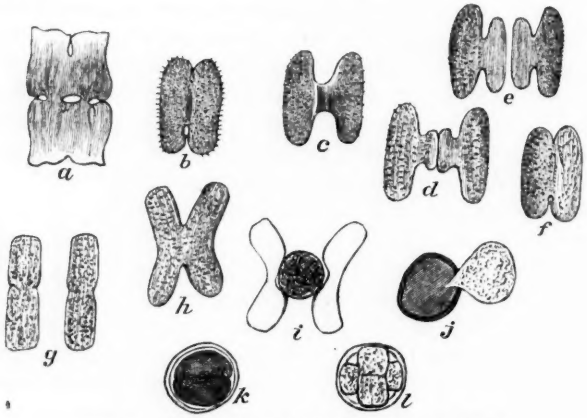
dividual forms four plants, each of which in turn gives rise to four more, so that often, under the microscope, these divisions can be traced through several generations on account of the difference



(Fig. 85.) DIVISION OF CELLS IN ALGÆ.

in size of the individuals and the relations which they bear to each other in space. (Figure 85, *b*, *c*, and *d*.) This simple asexual reproduction is the only method known in these lowest forms of plants.



(Fig. 86.) MULTIPLICATION OF DESMIDS BY DIVISION.

The Desmids form a large group of unicellular fresh-water plants, which have attracted much attention and study owing to the variety and beauty of the forms and markings which they

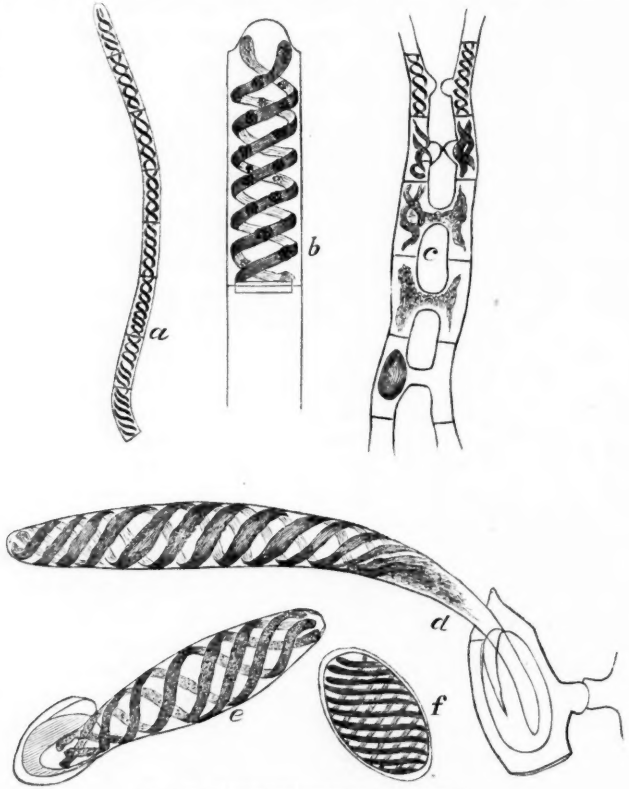
present. The general form of a desmid is usually very symmetrical, it being composed of two parts, of which the one is the exact counterpart of the other. (Figure 86, *a* and *b*.) The asexual form of reproduction is a cell multiplication by division, but differs somewhat from the cases already mentioned. When two desmids are to be made out of one, the first process is the elongation of the neck or part by which the two halves join (*c*). "By this time a new wall has formed inside each half of the isthmus and stretches also across its cavity, forming with its fellow a double partition wall separating the two halves of the old frond. Rapid growth of the newly formed parts now takes place, the central ends become more and more bulging as they enlarge, and in a little time two miniature lobules have shaped themselves at the position of the old isthmus [*d*]. At last, the parts thus formed having assumed the shape and appearance of the original lobules, the two fronds which have been developed out of one separate mostly before the new semicells [*e*] have acquired their full size."[1] This is much the most common form of reproduction, the other being the sexual method, and in one sense a process directly opposite to the one just described, it being the union of two cells to form one. When it is to take place, the outer walls of two desmids lying near each other burst open and the contents of each cell, with its thin inner wall, protrude; these finally blend, and the contents of the two cells flow into one mass (*i*). This new cell thus produced soon takes on a thick outer coat which is frequently ornamented with spines and other markings, and the ultimate result of the whole process is a spore.

In the Desmids the two cells which unite exhibit no sexual differentiation, and botanists have given to all such cases the name of *conjugation* in distinction from *fertilization*, where the male and female organs are apparent. But what becomes of the product of the two conjugated cells? It is a resting spore provided with a thick outer coat, and may sink to the bottom of the pond, where it remains through the winter. When the time for germination arrives its contents divide into a number of masses, each of which becomes a young desmid surrounded by a cell-wall of its own, and is turned out to take care of itself when the wall of the spore is broken away.

Thus far we have looked only at plants which are distinctly unicellular. Now we come to those that are made up of a number of single-celled individuals capable of existing alone, but usually arranged end to end in the form of filaments.

[1] Wood's Fresh-Water Algæ.

The members of the genus Spirogyra are very common in fresh-water ponds, making up much of the filamentous "scum" often seen on the surface. They are easily recognized under the microscope by their green spiral bands of chlorophyll (Figure 87, *a*, and still more enlarged in *b*). New individuals are formed by the simple division of the old cells by means of a partition wall

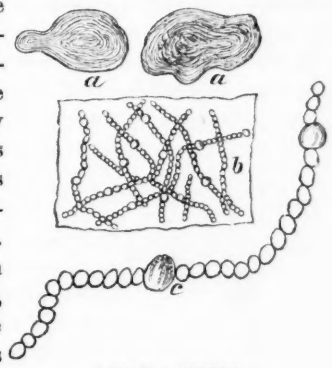


(Fig. 87.) REPRODUCTION OF SPIROGYRA.

through the middle; each half then grows to the normal size and again divides, thus increasing the length of the filament. Conjugation takes place between the cells of adjoining filaments. The first perceptible change is a contraction in the spirally arranged protoplasmic contents into a somewhat compact and irregular mass, followed by a bursting of the cell-wall, out of which a process is pushed, which, meeting with another similar one from

an adjoining cell, blends with it, and the contents of one cell pass over into the other. Two filaments can frequently be found lying nearly parallel, the cells of the one filament conjugating with those of the other throughout the whole length. In conjugation the deep green spiral bands are therefore destroyed, and in their place the dark brown spores are produced; so that in a floating mass of Spirogyra, when this process takes place, the beautiful green is lost and a pale, sickly, dirty material is seen in its stead, appearing as if dead when in reality only preparing itself to live over until another spring. Germination takes place by the contents of the spore pushing out into a filament, as shown in Figure 87, *d*, *e*, and *f*, drawn after a plate by Pringsheim, a noted cryptogamic botanist.

In the genus Zygnema, quite closely related to the Spirogyra, the spores often do not form in either of the cells, but remain in the enlarged centre of the uniting tube, leaving both filaments empty and giving a ladder-like appearance to the whole affair. Again, in other closely related genera, conjugation takes place between the adjoining cells of the same filaments by different methods in different species. In some a small tube is thrown out from each of the two cells, which meet and form a passage for the transfer of the contents of one cell to that of the other.



(Fig. 88.) NOSTOC.

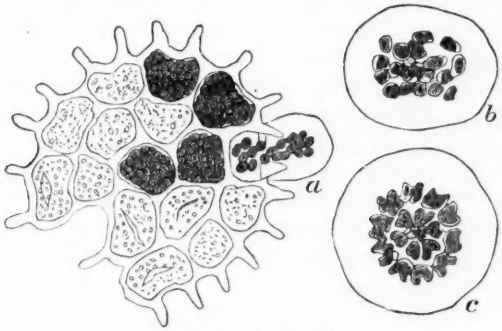
The Nostocs grow in water, but are more commonly found on damp ground as gelatinous spherical masses or colonies (Figure 88, *a*, *a*). When a small portion of one of these slippery balls is placed under the microscope it is seen to consist of a multitude of filaments, resembling strings of beads, imbedded in an amorphous jelly (*b*). In these strings there are at irregular distances certain cells, larger than the others, called heterocysts. In speaking of the method of reproduction of these plants we cannot do better than employ the language of Thurets, who has made a thorough study of them. He says: "The jelly of the old colony becomes softened by water, the portions of the threads lying between the heterocysts become detached, separate from the jelly and straighten, while the heterocysts themselves remain in the

jelly. After they have entered the water the old portions of the thread become endowed with motion, like the oscillatoreæ, and their exit is apparently caused by this movement. The roundish cells of the filaments now grow transversely, that is, vertically, to the axis of the filament, become disk-like, and then divide, the division planes being parallel to the axis of the old filament, which now consists of a series of short threads, the axis of whose growth is vertical to its own. The numerous threads which are thus formed continue to elongate and to increase the number of their cells; they then curve, place their two terminal cells in contact with those of the next row, and thus the whole unite into a single curved Nostoc-filament. Individual cells, apparently without any definite law, become heterocysts. In the mean time the gelatinous envelope of the new filament is developed, and the original microscopic substance attains or even exceeds the size of a walnut by continuous increase of the jelly and division of the cells."

In the Confervæ family reproduction is effected by means of motile asexual bodies called *zoöspores*. The members of the genus Cladophora, a portion of one of which is highly magnified in Figure 89, are quite common, deep green, irregularly branched algæ. When these zoöspores are to form, the protoplasmic contents of certain cells contract into oval masses, each of which upon its escape through the broken cell-wall moves away in the water by means of two vibratile cilia which are attached to one end of the spore. This rotary and progressive motion lasts for some time, after which the body comes to rest, loses its cilia, and, attaching itself to some support, germinates and produces a new Cladophora. There are frequently two distinct sizes of these asexual spores produced in separate cells of the same plant, as seen in the figure; the large ones are called macrozoöspores, and the small ones microzoöspores. It has been stated by Pringsheim that the microzoöspores conjugate, in which case we would have sexual action taking place between asexual spores. It is certainly quite interesting to see these little animal-like bodies moving rapidly around inside the mother cell, as well as darting away upon making their exit. Sometimes two or more

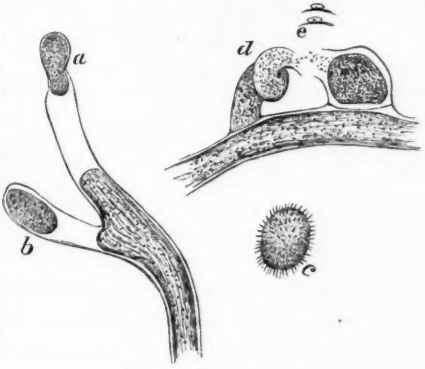
(Fig. 89.) CLADOPHORA.

will reach the opening at the same time when there is room for the passage of only one at a time, and even here among these protoplasmic forms there seems to be an exhibition of selfishness often bordering on wrath.



(Fig. 90.) PEDIASTRUM.

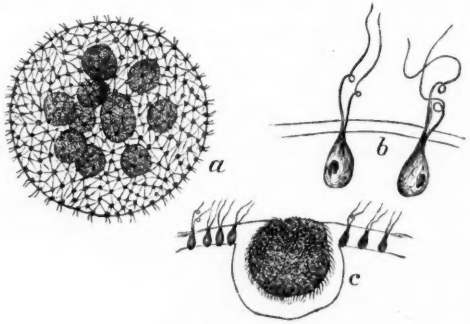
The family to which the Pediastrum belongs is distinguished by each cell forming a large number of motile spores, which remain together as they escape, and grow into a new disk-shaped cluster. In Figure 90 (which is a copy from A. Braun) is shown an old community where many of the cells have discharged their contents in a manner seen at *a*. Soon after the escape of a cell's contents a form as shown at *b* is assumed, the cluster being surmounted by a mass of jelly. A more advanced state of development is given at *c*, where the form of the mature community is discerned.



(Fig. 91.) VAUCHERIA.

The genus Vaucheria is a large one, and is made up of species of green, single-celled, often branching algæ, which grow most frequently on the moist borders of fresh-water streams. These plants are pleasant ones to study, and exhibit very well both sexual and asexual methods of reproduction. At *a* in Figure 91 is an enlarged portion of a filament, from the tip of one branch of

which a part of the contents is escaping, while in the other branch an oval body is seen. These represent the asexual spores, a more enlarged example of which is seen at *c*, and are nothing more than portions of the green protoplasmic contents of the filaments which contract and escape through the rupture at the tip. These spores are covered with a number of cilia, by the movement of which they are able to move about quite rapidly for a short time; then, coming to rest, they germinate, and produce a new Vaucheria. When a sexual spore is produced the process is somewhat different. At certain points on the filament, not far distant from each other, two projections arise: the one grows more slender than the other (*d*) and becomes much twisted upon itself. This is the male organ, called *antheridium*, and in it are produced the *antherozoids*, small bodies (*e*) provided with two cilia for movement; they resemble the zoöspores of the Cladophora, though having a quite different office to perform. The other projection is the



(Fig. 92.) VOLVOX.

female organ, *oögonium*, and is usually of an ovoid shape and filled with granular matter. When the time for fertilization comes, the wall of this organ is ruptured at the end nearest the antheridium, from which there passes out at the same time a mass of antherozoids, some of which find their way to the contents of the oögonium and fertilize it. Soon a new growth takes place in this newly fertilized body, and a double cell-wall is formed over it, the whole becoming a well-protected, resting spore; it is provided with no cilia and therefore has no movement of its own.

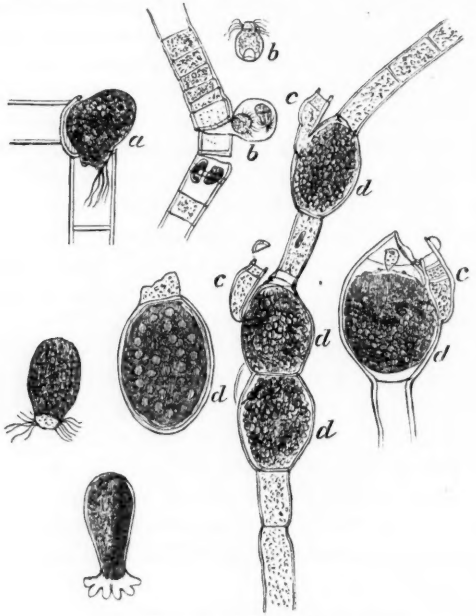
Is it not easy to trace the similarity between the sexual reproduction of Vaucheria and that of flowering plants?

The Volvocineæ comprise a peculiar group of plants, the mem-

bers of which are always in motion, and for this reason have often been classed in the animal kingdom. Figure 92, *a*, gives an enlarged view of a Volvox, which has the general appearance of a sphere studded over with a multitude of bodies arranged at quite regular distances and provided with two cilia. An enlarged view of a section of the outside of one of these spheres, with two of these ciliated bodies, is shown at *b*. Each of these bodies is considered an individual, and therefore the whole sphere is, like an oak-tree or grape-vine, a community of individuals. Asexual reproduction takes place by one or more of these individuals increasing rapidly in size and their contents dividing up into what are to develop into new individuals, forming thus a number of young communities within the old one, several of which are shown as dark, round bodies in *a*. When these young spheres have attained considerable size (*c*) they escape and become free and independent colonies. "The succession of generations of motile families is brought to an end by the formation of resting spores. The separate primordial cells of the last motile family lose their cilia, and surround themselves with a firm, closely adherent cell-wall. They accumulate at the bottom of the water, and there grow into large green balls, the color of which passes over when mature into red. Only when these resting cells have remained dry for a long time are they in a condition when again moistened to develop gradually generations endowed with motion. The sexual reproduction is brought about in this family by the gelatinous envelopes of the young families softening and setting free the separate cells, which move around by means of their cilia. When two of these cells meet they coalesce into a single body, the spore, which germinates and produces a new community after a period of rest."

Members of the genus Œdogonium grow frequently in stagnant pools and are not very attractive to the naked eye, though when viewed through the microscope they become objects of interest to many. Their somewhat complicated methods of reproduction are given so clearly by J. Sachs, in his Text-Book of Botany, that we cannot refrain from using his language in describing them, as well as copying the plate which he uses from Pringsheim. "The reproduction of the Œdogonieæ takes place by asexual swarm-spores and by oöspores produced sexually. An alternation of generations takes place in the following manner: From the oöspores which have remained at rest for a considerable period, several (usually four) swarm-spores are immediately formed,

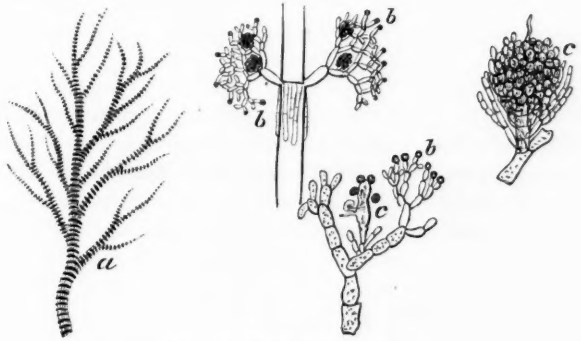
which produce asexual, that is, swarm-spore-forming plants, from which similar ones proceed, until the series of them is closed by a sexual generation (with formation of oösporés); but the sexual plants produce swarm-spores as well. The sexual plants are either monœcious or dioecious: in many species the female plant produces peculiar swarm-spores, out of which proceed very small male plants (dwarf males). The swarm-spore is developed in an ordinary cell of the filaments by the contraction of its whole protoplasmic substance (Figure 93, *a*); it becomes free from the



(Fig. 93.) ŒDOGONIUM.

mother-cell, the cell-wall splitting by a transverse slit into two very unequal parts. The swarm-spore is encircled at its hyaline end — the anterior end during swarming — by a crest of numerous cilia. The spermatozoids are very similar in form to the swarm-spores, but much smaller (*b*, *b*); their motion, due to a crest of cilia, is also less. The androspores, from which the dwarf male plants arise, are produced from mother-cells similar to those which give birth to the spermatozoids. After swarming they fix themselves to a definite part of the female plant, on or near the oögonium, and after germination produce at once the antheridium-

cells, and in them the spermatozoids (*c*, *c*, *c*). The oögonium becomes at first more completely filled with contents than the remaining cells; immediately before fertilization the protoplasm contracts and forms, as in Vaucheria, the oöspore, in the interior of which the grains of chlorophyll are densely crowded. Immediately after fertilization the oöspore surrounds itself with a membrane which afterwards, like its contents, assumes a brown color. The oöspore remains inclosed in the membrane of the oögonium, which separates from the neighboring cells of the filament and falls to the ground, where the oöspore passes its period of rest. When it awakes to new activity the oöspore does not itself grow into a new plant, but its contents divide into four swarmspores, which escape together with the inner skin of the oöspore, and, after this latter is dissolved, swim away. After becoming stationary each grows into a new plant."



(Fig. 94.) BATRACHOSPERMUM.

The last example, under this head, which space will admit of giving is one of a very few members of the family of red seaweeds, which condescends to live in fresh water, namely, Batrachospermum, or, as it is commonly called, frog-spittle. It grows in tufts upon the rocks and pebbles in the bottom of running streams, a small portion of which is shown in Figure 94, *a*, as it appears to the naked eye. The plant is made up of a central axis with a large number of branches radiating from it at quite regular intervals, giving a necklace-like appearance to the filaments. The male element is in the shape of small cells borne singly on the tips of the branches (*b*, *b*). The female part is a large, peculiar-shaped cell situated on a main branch down near the central cylinder (*c*). The antherozoids have no cilia, and fall from their attachments and are carried about by the water. When

one or more of them come in contact with the upper portion of the female cell they blend with it and their contents are absorbed and fertilization is effected. Soon a rapid growth of filaments and cells takes place at the base of the female organ as a result of this fertilization. In fact there is formed a naked cluster of spores (*c*) from these filaments, all fertilized by the single sexual act upon the central female cell.

In these few pages the endeavor has only been to point out a few of the leading methods of asexual and sexual reproduction among fresh-water algæ, and we feel in closing that the vast subject has been but here and there touched upon. But enough has been said to show that even in these lowly forms the *too often supposed* sameness of reproduction loses itself in variety of methods and multiplicity of changes.

SURFACE GEOLOGY OF THE MERRIMACK VALLEY.[1]

BY WARREN UPHAM.

THE highest fountains of Merrimack River are Eagle Lakes, on Mt. Lafayette, 1090 feet below its summit and 4170 above the sea. The source of the straight river is a lake which lies in the deep Franconia Notch, beneath the jutting rocks of the Profile. This stream is at first inclosed by high mountain ranges, and descends more than 1200 feet in its first nine miles. Distances and heights along this river are as follows: Profile Lake, about 1950 feet above the sea; mouth of East Branch, 9 miles, 710; at Plymouth, 28 miles, 468; at New Hampton, 39 miles, 438; mouth of Smith's River, two miles below Bristol, 45 miles, 320; mouth of Winnipiseogee River at Franklin, 55 miles, 269; mouth of Contoocook River at Fisherville, 66 miles, 249; mouth of Soucook River, 76 miles, 199; Amoskeag Falls at Manchester, 89 miles, 179 to 123; at line between New Hampshire and Massachusetts, 108 miles, 90; Pawtucket Falls dam, Lowell, 117 miles, 87; Essex Company's dam, Lawrence, 128 miles, 39. The entire length of this river is about 155 miles, and its last twenty miles are affected by the tide.

The Merrimack Valley in New Hampshire is comparatively straight, and forms a continuous line of depression which is a principal feature in the topography of the State. Its course is

[1] This essay is principally based upon explorations made for the Geological Survey of New Hampshire, and will be more fully presented in vol. iii. of the report on that survey.

slightly east of south. The upper and lower portions of the river which occupies this valley are known by different names. For more than fifty miles from its source, this river is called Pemigewasset; and the name Merrimack is applied to it only from the confluence of the Winnipiseogee River with the Pemigewasset at Franklin.

After entering Massachusetts the river turns to the east at North Chelmsford, and thence pursues a devious east and northeast course at right angles to its valley in New Hampshire. It here threads its way among hills, with no distinct, wide valley; and only low water-sheds divide it from adjoining basins on the south.

In considering the surface geology of Merrimack Valley, we will begin at its head and describe first the modified drift which forms conspicuous plains, terraces, and intervals or bottom-lands along its course in New Hampshire, and occurs in gravel ridges, similar to the *Kames* of Scotland, well shown at many places along the whole course of this river; next, the prominent rounded hills of coarse glacial drift or *till*, which are finely displayed along this river in Massachusetts; and, last, the marshes and beaches at its mouth. After this, we will inquire what these deposits teach in regard to the history of this valley in the glacial age, during the melting of the great northern ice-sheet, and since that time.

The modified drift of the upper part of the Merrimack, called Pemigewasset River, is usually one half mile to one mile wide, and is bordered on both sides by high hills or mountains. Below Franklin the modified drift is usually one to two miles wide; its greatest development is in Concord, in Merrimack, and in Litchfield, where it has a width of nearly four miles. The hills which border this part of the valley rise with comparatively gentle slopes, and the lowest points of its eastern water-shed are only three hundred and fifty to six hundred and fifty feet above the sea.

On Pemigewasset River modified drift occurs first in Lincoln, five miles from Profile Lake. This is very coarse, water-worn gravel, containing pebbles six inches to one and a half feet in diameter, or sometimes larger. It has an irregularly smoothed surface, imperfectly terraced, with its outer margin twenty feet above the stream. From this point modified drift is continuous on one or both sides of the river for thirty miles. In the first seven miles, to Woodstock village, it consists wholly of gravel of

different degrees of coarseness. Southward, banks and terraces of sand begin to appear, but gravel still predominates for a long distance below. The stream here frequently occupies a broad, shallow channel paved with pebbles of all sizes up to two feet in diameter, with little admixture of fine gravel or sand, which accumulates only in deep or sheltered places.

For ten miles south from the mouth of East Branch, or nearly to the south line of Thornton, a high terrace of gravel or sand is commonly well shown on both sides of the river, and has a uniform, continuous slope of fifteen feet to the mile. This slope is nearly the same as the descent of the river, which has evidently swept away this deposit to a depth of from seventy to one hundred feet over the area occupied by its channel and bordering bottom-land or interval. Nowhere else in New Hampshire is the erosion of the modified drift, by which it has been shaped in terraces, so clearly displayed. Here it seems certain that a former flood-plain, ten miles long, has been terraced as we see it by the excavation of the river.

In Campton the Pemigewasset receives two considerable tributaries from the east, Mad and Beebe rivers, which drain basins on the northwest and southeast of the mountain range that culminates in Sandwich Dome. South of the Beebe River the upper terrace, increased in height by alluvium from the tributary, forms a pine-covered plain, one mile long and a half mile wide. These "pine plains," appearing in a few places on the Pemigewasset and commonly along the Merrimack, form one of the characteristic features of this valley.

In Plymouth and Holderness both the high plain and interval are finely shown, and the extent of the alluvial area, at one point a mile and a half wide, is greater than at any other place on Pemigewasset River.

Dunes. In the north part of New Hampton and in many places for thirty miles southward to the north line of Concord, we find numerous dunes or sand-drifts lying at various heights on the east side of the valley up to three hundred feet above the highest terraces. These dunes appear in large amount and reach their greatest height near their beginning, two miles south of Ashland. Here the sand-drifts, one to five feet deep, are strewn in a pathway ten to twenty rods wide, which extends a quarter of a mile along the hill-side, with a northwest-southeast course, rising three hundred feet above the ordinary modified drift, or to a height about eight hundred and fifty feet above the sea.

These dunes occur only on the east side of the valley, consist wholly of fine sand, and lie in trains which ascend from the highest terrace in a southeast direction along the hill-side. All these characteristics indicate that they owe their origin to the transportation of sand, by the prevailing northeasterly winds, from the plains below, probably at the period when these had their greatest extent, prior to their excavation by the river, and, we may presume, before the appearance of a forest. They are usually made conspicuous at the present time by being blown in drifts, which are so constantly changing that they give no foothold to vegetation; but when they occur at considerable heights the lower portion of the series is generally grassed over, making the upper drifts appear isolated on the hill-side. The whole train of dunes before mentioned is equal by estimate to a mass one thousand feet long, fifty feet wide, and two feet deep, thus containing one hundred thousand cubic feet or five thousand tons, which has been raised by the wind an average height of one hundred and fifty feet.

Another very good illustration of this transporting power of the wind is found in Sanbornton, one mile southeast from Hill. Here, as also in New Hampton, the ancient dunes have been swept forward anew since the land was cleared. The sand from a hollow one hundred and fifty feet long, forty feet wide, and two to five feet deep has been carried, in long northwest-southeast drifts, two hundred to four hundred feet farther and twenty-five to thirty feet higher up the hill. The depth of recent excavation is shown by a large stump which has been thus undermined.

Similar dunes, high above the ordinary modified drift, occur along the east side of Connecticut River in New Hampshire and southeast from Ossipee Lake.

From New Hampton to Bristol the river flows westerly, almost at right angles with its general direction, descending by a nearly continuous slope eighty-six feet in the four miles, this being the most rapid portion of its course south of East Branch. Here it is closely bordered by sloping hills, and differs from all the rest of this valley in New Hampshire in being well-nigh destitute of modified drift. The high terraces reappear below Bristol, and thence to Franklin have a height one hundred and fifty to one hundred and seventy-five feet above the river.

From Franklin to the Massachusetts line the ancient high flood-plain of the Merrimack is everywhere well shown by conspicuous terraces. Along much of the way these terraces expand

on one or both sides into wide sandy "pine plains," so called because their principal wood-growth consists of white or pitch pines. These are often accompanied by a thick and tangled undergrowth of scrub oaks, which, with the pitch pines, flourish best on these barren plains. The terraces have a very level surface, with a regular but slight slope, which amounts to nearly the same as the descent of the river.

At Franklin the upper terrace is well defined upon both sides of the valley. It has here considerable fall in a short distance, being four hundred and forty-five and four hundred and forty feet above the sea at the north side of Webster Brook and Winnipiseogee River, and descending in less than a mile to four hundred and thirty and four hundred and twenty at their south side. In the next nine miles the upper terrace falls to a height one hundred and twenty-five feet above the river, which continues for more than twenty miles to the north part of Manchester, the highest terrace seeming to descend most rapidly near the present falls of the river, so that a nearly uniform height above the river is maintained.

In Canterbury the upper terrace spreads out into plains which are at some places a mile wide. The Boston, Concord, and Montreal railroad through this town is upon these high plains, while the Northern railroad in Boscawen and Concord lies on the lowest terrace, being embanked much of the way to raise it above the floods of spring. The plains of the south part of Canterbury, extending one mile into Concord, show an unusually rapid, continuous slope, amounting to eighty feet in four miles, or from one hundred and thirty to only fifty feet above the river. The north end of this slope appears to be at the normal height, representing the level of the river at the time of deposition of these plains, while its south end is about seventy feet below this normal line, which is here shown on the west side in the plains north and south of Fisherville.

Boscawen village is built on the south end of a similarly sloping terrace, three miles long, in which distance it falls thirty feet, and we find thirty feet more fall of the same terrace in less than a mile along the village street. The whole of this terrace is below the normal height, showing a deficiency of fifteen feet at its beginning and of forty feet at the north end of Boscawen village.

The supply of alluvium brought down by the river at this point was not sufficient to fill the valley to its average depth.

The lower portions of these slopes were probably sixty feet below the surface of water, which was held back by the extensive plains brought in from the Contoocook and Soucook valleys. These plains have their greatest development on the east side of Merrimack River, extending six miles from above East Concord to the mouth of the Soucook. Their area of greatest width, which exceeds two miles, is opposite the city of Concord.

In Boscawen and Canterbury and through Concord, the lowest terrace for twelve miles occupies a wide area, of which a large part is overflowed by the high water of spring, forming the only extensive interval on this river south of Plymouth. Fine views are here afforded at the edge of the plains, whose high bluffs descend abruptly a hundred feet, overlooking the fertile intervals and the windings of the river for miles north and south.

Ancient river-beds are indicated at many places by shallow ponds, which lie in long and frequently curved depressions of the bottom-land. Horseshoe Pond is one of these, situated at the north end of Main Street, in Concord. It is shaped like a crescent, being a half mile long, nearly as wide as the present channel, and six feet above the ordinary height of the river. Its middle portion lies at the foot of a higher terrace, against which the river once swept its full current. The nearest point of the present channel is a half mile distant at the north, where the river bends and now directs its current against Sugarball Bluff, a mile and a half northeast from Horseshoe Pond. The date of these changes cannot be stated; they occurred before the first settlement here, one hundred and fifty years ago.

On the east side of the "Fan" or broad interval opposite the north part of the city of Concord, the river formerly flowed by a very circuitous route four hundred and sixty rods, which was shortened to one hundred and fifty rods by great freshets, in 1826, 1828, and 1831, cutting a direct course across two peninsulas. Ponds occupy portions of the old channel. Sugarball Bluff, one hundred and twenty-five feet in height, which forms the edge of the sand plain near this place, is now being rapidly undermined. At Davis's Bluff, a mile to the south, and of about the same height as Sugarball Bluff, a width of three rods has been swept away in as many days. Erosion at this point has continued thirty years, requiring a dwelling-house near the edge of the bluff to be several times moved and the road changed.

These recent incursions of the river upon the plains, and the ordinary changes in its channel upon the intervals, washing away

yearly from one bank and adding to the side opposite, leave no doubt that the river has flowed at the foot of the bluffs along their whole extent, occasionally making a deep excavation beyond its usual bounds, as on the east side south of Sugarball Bluff; that the high plain originally filled the whole valley; and that the river has swept many times from side to side over the space occupied by its lower terraces and interval.

Valuable beds of clay, extensively used for brick-making, occur in the highest terrace for four miles north from Hooksett upon the east side. This clay appears to form a nearly continuous stratum, which has a thickness of twenty to thirty feet, with its top about one hundred feet above the river. It is overlaid by a few feet of sand. The upper half of this stratum consists of a hard and compact *gray clay*. At a depth of ten to fifteen feet this is frequently separated by a thin layer of sand, one fourth of an inch to three inches thick, from the underlying *blue clay*, which is soft and plastic when dug from the bank. These divisions are nearly equal in amount, but in some of the brick-yards only the upper gray clay is exposed. The same gray and blue clay, the latter always below the former, are frequently found in the southeast part of New Hampshire and along Hudson River and Lake Champlain.

At Amoskeag Falls the alluvium is two miles wide, and it averages thus for three miles below, the city of Manchester lying at the middle of this distance on the east side. The greater part of this area consists of high sandy or gravelly plains, whose barrenness made this township, under its former name of Derryfield, proverbial for poverty. The falls were then utilized only as a fishing place. The river here descends fifty-six feet, and its water-power has within fifty years built up the largest city in the State.

In Merrimack and Litchfield the high sandy plains have a larger development than in any other portion of this valley, excepting Concord. On the east side the modified drift occupies almost the entire township of Litchfield. An area one fourth to three fourths of a mile wide next to the river is the fertile low terrace, which is partly interval, as opposite the mouth of Souhegan River, but lies mostly somewhat above high water. East of this is the plain, about one hundred feet above the river, having the same height as in Merrimack on the west.

The sand and gravel of the plain between Nashua River and Salmon Brook, on which the principal part of the city of Nashua

is built, appear to have been brought partly by each of these streams and partly from the northwest along the avenue followed by the Wilton railroad, where no stream now exists. A continuous belt of alluvium, upon which this railroad is built, extends six miles from the Souhegan River in Amherst to the plains near the mouth of Nashua River. Its narrowest place, three miles from the city, is a third of a mile wide, while its widest portions, in the northwest corner of Nashua and south part of Amherst, are one and a half miles wide. These plains consist of horizontally stratified sand and gravel, and show a gradual descent from northwest to southeast, amounting to seventy-five feet in the six miles.

Kames. Remarkable ridges of coarse, water-worn gravel, frequently interstratified with layers of sand, and sometimes inclosing large, angular bowlders, occur in the Merrimack Valley in Thornton, Franklin, Boscawen, and Concord; in a series twenty miles long, which extends from Loudon along Soucook River to its mouth, and thence along the west side of Merrimack River to Manchester; in Nashua and Hudson; in another series, which has been traced by Rev. George F. Wright, of Andover, extending about twenty-five miles, through Methuen, Lawrence, Andover, Wilmington, North Reading, and Reading, to Wakefield; along Brandy Brow Brook in Haverhill, and thence continuing southward in a series similar to the last; and in Newburyport.

The plains, terraces, and intervals consist of fine gravel, sand, clay, or silt, horizontally stratified; but these ridges are mainly composed of very coarse, water-worn gravel, often containing stones two or three feet in diameter. When the gravel is mixed with layers of sand, as is frequently the case in the entire section of a ridge, these materials are very irregularly bedded, portions of them dipping at a high angle, giving the whole a rudely anticlinal or arched stratification. In many of these ridges, however, a section shows no beds of sand, and almost no marks of stratification; but there is still evidence that the deposit was formed by a current of water. It contains only the smaller bowlders which would be thus separated out from the coarse glacial drift or till; these have been more or less rounded by water-wearing, being quite different from the glaciated stones of the till, while the sand and clay have been mostly swept forward by the strength of the current. Wherever the ordinary fine alluvium has been deposited it overlies or in part covers the gravel ridges, which are therefore the oldest of our modified drift deposits. Similar

ridges of gravel have been often described by European geologists, under the various names of *kames* in Scotland, *eskers* in Ireland, and *åsar* in Sweden.

In Concord these kames form the uneven east part of Blossom Hill cemetery, and extend south one and a half miles. The south end of this series is a single steep ridge twenty-five to forty feet high, called Whale's Back, which originally extended a quarter of a mile. Its north portion has been used by the city in making and repairing streets. No kame-like deposits were discovered along the east side of the river in Concord, the whole mass of the plains being fine alluvium.

Similar ridges were next found just below the mouth of Soucook River, exposed by railroad excavation on both sides of the Merrimack. The kame here cut through by this river is a portion of a series which extends twenty miles, from Loudon to Manchester. The greater part of these kames consist of very coarse, water-worn gravel, containing pebbles six inches to two feet in diameter, with no intermixture of clear sand. They are disposed in irregular ridges of southerly trend with the valley, sometimes single, but more often with irregular branches, or several are parallel to each other. Their height varies from sixty to one hundred and twenty-five feet above the river, and they are often covered, or nearly so, by the alluvium of the plains. Upon the Soucook River these kames are repeatedly cut through by its present channel, as also near its mouth by the Merrimack, but in the fourteen miles farther south they lie wholly on the west side of the Merrimack, near the edge of its alluvial area.

This series of kames and others observed along Merrimack River in New Hampshire, the single continuous kame, one hundred and fifty to two hundred feet in height, which extends twenty-four miles along Connecticut River from Lyme, N. H., to Windsor, Vt., and a notable series which extends from Saco River at Conway to Six-Mile Pond, and from Ossipee Lake southeastward along Pine River, all lie in the middle or lowest parts of the valleys, which are bordered by high ranges of hills.

The kames which we have next to consider do not follow the present water-courses, but run directly across the Merrimack and other rivers, which here have no well-marked valleys, being not much lower than the hollows between the hills on either side. Occupying these hollows, the kames extend long distances in a somewhat devious but, for the whole series, quite straight course, which is about half-way between south and southeast.

A portion of the Andover series of kames was described by Dr. Edward Hitchcock,[1] in 1842, which appears to be the earliest notice of these peculiar gravel ridges in America. He writes: "The most common and most remarkable aspect assumed by these elevations is that of a tortuous collection of ridges and rounded and even conical hills, with corresponding depressions between them. These depressions are not valleys which might have been produced by running water, but mere holes, not unfrequently occupied by a pond."

The extent of this series was at first supposed to be about one and a half miles, but Rev. George F. Wright[2] has recently traced it fully twenty-five miles, from Methuen to Wakefield. He has also traced a second parallel series, which lies about seven miles farther east, passing through Haverhill, Groveland, Georgetown, Boxford, Topsfield, and Wenham. These ridges "are ordinarily composed of sand, gravel, and pebbles, the latter from a few inches to two or three feet through, sometimes irregularly stratified, the coarse material being as likely to abound near the top as at the bottom; at other times ten or fifteen feet or more in thickness will give no sign of stratification whatever. . . . . The fragments of rock in the ridges are nearly all somewhat rounded and apparently water-worn." The first of these series is well shown in Lawrence, a short distance southeast from the water-works reservoir. On the west side of Shawshin River, opposite Andover village, it consists of three parallel kames, known as East, Indian, and West ridges, which are respectively forty, fifty, and ninety feet high. The last two inclose a bog filled with peat and mud, twenty to thirty feet deep. The base from which these measurements were taken was forty feet above Shawshin River and ninety feet above the sea.

Prominent hills, composed of unmodified drift or till, are scattered here and there along the course of the Merrimack River through Massachusetts, and in some townships are almost as thickly set as possible. These remarkable accumulations of till are readily recognized because of their smooth and regular contour. From their resemblance in shape to a lens, Prof. C. H. Hitchcock has denominated them *lenticular hills*. They are oblong or sometimes nearly round, with steep sides and smoothly rounded tops, and vary from an eighth of a mile to a half mile in length, and from forty feet to two hundred feet in height. Their

[1] Transactions of the Association of American Geologists and Naturalists.

[2] Proceedings of the Boston Society of Natural History, vol. xix., pp. 47–63.

longest axis has most frequently a northwest-southeast trend, coinciding nearly with the course of striæ on ledges throughout this part of New England. This is well seen on the north side of the Merrimack, notably in East Kingston, Kensington, and South Hampton, N. H.; but there are many exceptions on the south side of this river.

The till on the surface of these hills is comparatively loose and sandy, brownish or yellowish in color, and contains frequent bowlders up to five feet or more in diameter, many of which are angular and wholly unworn. At a depth of two or three to fifteen or twenty feet, this *upper till* is succeeded by the very compact, clayey, and dark or bluish *lower till*, which contains few large bowlders, but is thickly filled with stones up to one or two feet in diameter, nearly all of which are glaciated, having beveled or striated sides and rounded edges.

Typical examples of these drift hills are Bear Hill in Methuen; Silver's, Golden, and Great hills in Haverhill; Morse Hill in East Kingston; Moulton Ridge, Martin, and Horse hills in Kensington; Indian Ground and Chair hills in South Hampton; Whittier's Hill in Amesbury; Powow Hill in Salisbury; Prospect Hill in Andover; Hazeltine and Dead hills in Bradford; Bald Pate Hill in Georgetown; and Crane Neck and Archelaus hills in West Newbury.

Modified drift is scanty or wanting along this part of Merrimack River. The floods from which it was deposited seem to have kept their straight course and carried the most of their alluvium southward, passing over the very low water-shed between Lowell and Massachusetts Bay. A conspicuous sand terrace at Haverhill was brought down by Little River. Its steep escarpment shows that much of this deposit has been undermined by the Merrimack.

Part of the city of Newburyport is built on a broadly rounded ridge of gravel and sand, which probably had a similar origin with the narrower and steep ridges of the kames. This deposit appears first in the south part of Amesbury. It has been cut through by Merrimack River, and on its opposite side rises to a height of about one hundred and fifty feet in Moulton's Hill. A quarter of a mile farther southeast it is depressed to seventy five feet, and shows the sharp ridges and knolls of typical kames. From this point it extends with a nearly uniform height of about one hundred feet along High Street to the middle of the city, and thence continues on the southwest side of this street to the

Upper Green. Here it is interrupted for a little distance, beyond which it lies on the northeast side of this street, extending to within a half mile of Old Town Hill. The entire length of this ridge is six miles. No other high deposits of modified drift are found in this vicinity, and wide areas of lowland border it on both sides. Excavations in the northwest part of the city show the ridge there to be composed mainly of water-worn gravel, with the largest pebbles about a foot in diameter. A railroad cut, known as March's Hill, two miles farther southeast, has only occasional layers of gravel, with the largest pebbles six inches in diameter, very irregularly interstratified with sand, which is here four fifths of the whole deposit. The depth of modified drift forming this ridge is shown by wells to be from fifty to ninety feet.

At the mouth of Merrimack River a ridge of sand, twenty-five to fifty feet high and ten to forty rods wide, extends for several miles both to the north and south, facing the ocean. Marshes a mile wide, with their surface two or three feet below the highest tides, lie on the west side of this ridge. Its gentle eastern slope forms the beaches of Salisbury and Plum Island. For a quarter of a mile or more out from these beaches the water is shallow, and the waves break upon shifting banks of sand. The ridge is built up or washed away by the same cause, and is also channeled and heaped into mounds by the winds, which are constantly changing its form.

The mouth of the river has varied much during the past sixty-five years. A fort built in 1812 at the north end of Plum Island remained at one time three fourths of a mile north from the river's mouth on Salisbury Beach. Subsequent changes have brought the river back, so that now it flows out to sea at nearly the same point as in 1812.

We having now examined the recent geological records of this valley, it remains for us to seek their order and meaning. The edges of the lenticular hills of till are overlaid by the kames, and these are in turn partly covered by the alluvium of the plains and terraces. The till is, therefore, the oldest of these deposits.

This extraordinary formation, and the rounded form and striation of exposed ledges, observed in all countries where till is found, presented one of the most difficult problems of geology, which has been solved and made clear by a theory too wonderful ever to have been conjectured, were we not led to it by abundant and undeniable testimony. This theory was first brought out prominently by Agassiz in 1840, and was based upon his studies

of the glaciers in the Alps. These fields and rivers of ice, several hundred feet in depth, are found descending from the regions of perpetual snow, their rate of motion being one to five hundred feet, or even more in their steepest portions, in a year. Many angular blocks and fragments which fall from the bordering cliffs are carried along on the surface of the ice, or are contained in its mass, with others torn from the rocks over which it moves, and under its vast weight these act as graving tools to round and striate the ledges beneath. The similar striation of all northern countries and the formation of the till have been effected by a uniform cause, namely, a moving ice-sheet which overspread the continents from the north.

This continental glacier had accumulated sufficiently deep to cover every mountain summit in New Hampshire. That it overtopped Mt. Washington is fully proved by recent discoveries of Professor C. H. Hitchcock, the state geologist. Its thickness farther to the north was so much greater than in this latitude that its immense weight caused the ice to flow slowly outward, and the direction of its current in New England was to the south and southeast. By this motion fragments were torn from the ledges, and a large part of these were sooner or later held in the bottom of the ice and worn to a small size by friction upon the surface over which it moved. The resulting mixture formed beneath the ice is the ground-moraine or *lower till*. Its dark and frequently bluish color is due to seclusion from air and water during its formation, as pointed out by Torell, leaving its iron principally in the form of ferrous silicates or carbonates; and its compactness and hardness have resulted from compression under the great weight of ice. While this deposit was thus accumulating beneath the ice, great amounts of material, coarse and fine, were swept away from hill slopes and mountain sides, and afterward carried forward in the ice. When this melted a large portion of the material which it contained fell loosely upon the surface, forming an unstratified deposit of gravelly earth and bowlders, called *upper till*. It will be seen that the upper member is the one usually exposed at the surface, and it is often the only one present where only a thin covering of till is found. Its characteristics are the larger size of its bowlders, which are mostly angular and unworn; the yellowish color of its fine detritus, produced by the hydrated ferric oxide to which its iron has been changed by exposure to air and water; and the comparative looseness of its whole mass.

Frequently about Winnipiseogee Lake, and rarely elsewhere, de-

posits of stratified clay or sand are found between the lower and upper till. In these places the contour of the land seems to have prevented free drainage from the foot of the melting ice-sheet. The water then melted large open spaces beneath the ice near its margin, in which these beds of stratified drift were deposited. The overlying till was contained in the ice-sheet, and fell upon the surface when its melting was completed.

The distribution of the till in this valley is quite irregular. Sometimes no considerable accumulations of it are seen for several miles, and the ledges lie at or near the surface. Elsewhere the till occurs in large amount, covering the ledges which are scarcely exposed over some whole townships near the coast. Wherever it is found plentifully it is to a large extent massed in the peculiar lenticular hills, which, except a thin layer on the surface, are entirely composed of lower till; but we cannot explain how the ice acted to accumulate its ground-moraine over some sections in these regular hills, while over other large areas, apparently not otherwise different, they are wholly wanting.

The departure of the ice-sheet was attended with a comparatively rapid deposition of the abundant materials which it contained. It is probable that its final melting took place mostly upon the surface, so that at the last great amounts of detritus were exposed to the washing of its innumerable streams. The surface of the ice-sheet became molded by this process of destruction into great basins and valleys, and the avenues by which its melting waters escaped came gradually to coincide with the depressions of our present surface. When the glacial river entered the open area from which the ice had retreated, or in the lower part of its channel while still walled on both sides by ice, its current was slackened by the less rapid descent, causing the deposition first of its coarsest gravel, and afterwards, in succession, of its finer gravel, sand, and fine silt or clay. The valleys were thus filled with extensive and thick deposits of modified drift, which increased in depth in the same way that additions are now made to the bottom-lands or intervals of our large rivers by the annual floods of spring. The portion of the material contained in the ice-sheet which escaped this erosion of its streams formed the upper till. The abundant deposition of drift, both stratified and unstratified, during this final melting of the ice-sheet has been brought into its due prominence by Prof. James D. Dana, who denominates this the *Champlain period*, deriving the name from marine beds of this era which occur on the borders of Lake Champlain.

The oldest of our deposits of modified drift are the *kames*. From the position of these peculiar accumulations of gravel, which are overlaid by the horizontally stratified drift, the date of their formation is known to be between the period when the ice-sheet moved over the land and that closely following, in which this more recent modified drift was deposited in the open valleys from the floods that were supplied by the melting ice. We are thus led to an explanation of the kames which seems to be supported by all the facts observed in New Hampshire and Massachusetts, and which appears to apply also to the similar deposits that have been described in other parts of the United States and in Europe.

The melting of the ice-sheet over New England advanced from the sea-coast towards the north and northwest. The lowest and warmest portions of the land were probably first uncovered, and as the melted area advanced into the continental glacier its vast floods found their outlet at the head of the advancing valley. This often took place by a single channel bordered by ice-walls, as was the case along the Connecticut kame; but in the Merrimack Valley and in Eastern Massachusetts, these glacial rivers also frequently had their mouths by numerous channels, which were separated by ridges of ice. In these channels were deposited materials gathered by the streams from the melting glacier. By the low water of winter layers of sand would be formed, and by the strong currents of summer layers of gravel, often very coarse, which would be irregularly bedded, — here sand and there gravel accumulating, and, without much order, interstratified with each other. Sometimes the melting may have been so rapid that the entire section of a kame may show only the deposition of a single summer, which would then be very coarse gravel without layers of sand. When the bordering and separating ice-walls disappeared, these deposits remained in the long ridges of the kames, with steep slopes and irregularly arched stratification. Very irregular short ridges, mounds, and inclosed hollows resulted from deposition among irregular masses of ice. The *glacial rivers* which we have described appear to have flowed in channels upon the surface of the ice, and the formation of the kames took place at or near their mouths, advancing as fast as the ice-front retreated.

The extensive level *plains and high terraces* which border our rivers, constituting the most conspicuous and by far the largest portion of our modified drift, were also deposited in the Champlain period. The departing ice-sheet was the principal source

both of the vast amount of material and of water for sweeping it into the valleys, which appear in most cases to have been thus filled to the level of their highest terraces. The prevailing horizontal stratification of these deposits shows that they were spread over large areas by the current of the floods which held them in suspension. The modified drift thus increased in depth in the principal valleys through a long period, which may have continued till the last of the ice at the heads of the valley and of its tributaries had disappeared.

During the recent or *terrace period* the rivers have been at work excavating deep and wide channels in this alluvium. The terraces mark heights at which in this work of erosion they have left portions of their successive flood-plains. As soon as the supply of material became insufficient to fill the place of that excavated by the river, a deep channel was gradually formed in the broad flood-plain. This process was very slow, allowing the river to continue for a long time at nearly the same level, undermining and wearing away its bank on one side, and depositing the material on the opposite side, till a wide and nearly level lower flood-plain would be formed, bordered on both sides by steep terraces. When the current became turned to wear away the bank in the opposite direction, a large portion of this new flood-plain would be undermined and redeposited at a lower level; but the direction of the current's wear might be again reversed in season to leave a narrow strip which would then form a lower terrace. In this way the Merrimack River through New Hampshire has excavated its ancient high flood-plain of the Champlain period to a depth of seventy-five to one hundred and fifty feet, for a width varying from an eighth of a mile to one mile. In Canterbury and Concord we see the highest plain is being now undermined by the wear of the current, forming steep bluffs.

The very fine character of the materials which compose the lowest terraces and the interval or present flood-plain is due to this wearing away and redeposition by the river, which have been many times repeated, till what may have been at first gravel becomes very fine sand or silt. By each removal this alluvium is made one degree finer, and is deposited at a lower level and farther down the stream. The end of its slow journey is the ocean, where it will help to make the sedimentary rocks of this epoch. It has completed a great cycle of changes, ending where the upheaved and contorted ledges from which it was derived had their remote beginning.

ON CRITICAL PERIODS IN THE HISTORY OF THE EARTH, AND THEIR RELATION TO EVOLUTION; ON THE QUARTERNARY AS SUCH A PERIOD.[1]

BY JOSEPH LECONTE.

IN the series of rocks representing the history of the earth there occur at different horizons *unconformities*. In most cases these are not found at the same horizon in different places; but there are a few which seem to be very general. Associated with these unconformities, as is well known, there is nearly always a marked change in the fossil species. The greatness of this change is invariably in direct proportion to the generality of the unconformity. These general unconformities attended with very great changes in organic forms are the natural boundaries of the great divisions of time, and the less general unconformities attended with less sweeping change of organic forms, of the subdivisions of time.

The earlier geologists, under the influence of the *then* dominant idea of frequent supernatural interference with the course of nature, imagined that these unconformities marked the times of instantaneous cataclysm which disturbed the rocks and destroyed all living things, sometimes locally, sometimes generally, and that these exterminations were followed by re-creations of other and wholly different species at the beginning of the subsequent period of tranquillity. *Now*, however, we believe that no such instantaneous general exterminations and re-creations ever occurred. We know that unconformity simply indicates eroded land-surface, and therefore marks a period of time during which the observed place was land and received no sediment; that two series of rocks unconformable to each other denote two periods of comparative quiet, during which the observed place was sea-bottom, receiving sediment steadily, separated by a period of oscillation producing increase and decrease of land, during which the observed place was raised into land-surface, with or without crumpling of the strata, deeply eroded, and then sunk again below sea level to receive the second series of strata. The length of the two periods of repose is roughly measured by the thickness of the two conformable series. The length of the period of commotion is roughly measured by the amount of erosion at the line of unconformity.

[1] Read before the National Academy of Sciences, April 18, 1877. (Reprinted from the American Journal of Science and Arts, for August, 1877.)

Evidently, therefore, every case of unconformity marks a period of time — often a long period — during which there was no record made in strata and fossils at the observed place; certain leaves — frequently very many — are there missing from the Book of Time. Is it any wonder, then, that skipping over these pages when we commence reading again we find the matter entirely new? Evidently, the suddenness of the change in organic forms is only apparent. If we could recover the record, which was doubtless carried on elsewhere, the break would disappear; if we could find the missing leaves the reading would be continuous. In every such instance, therefore, there is a *lost interval* of history. In cases of local unconformity we recover the lost record in other places, and thus fill up the blank in the history. But in some cases of very general unconformity, such as those which mark the great divisions of time, the loss is not yet recovered, perhaps is irrecoverable, though doubtless the more complete knowledge of the geology of the whole earth surface will go far toward filling blanks and making the record continuous.

The view above presented is now held by all geologists, but there seems to be danger, under the influence of the *now* dominant views of evolution, of erring on the other extreme. Assuming a *uniform rate* of evolution, many, it seems to me, commit the mistake of measuring the amount of lost interval by the amount of change of organic forms, and thus discredit the real value of the geological record by exaggerating greatly its fragmentary character. On the contrary, there appears good reason to believe that the evolution of the organic kingdom, like the evolution of society and even of the individual, has its periods of *rapid movement* and its intervals of *comparative repose* and readjustment of equilibrium. Geological history, like all other history, has its periods of comparative quiet, during which the forces of change are gathering strength, and periods of revolution, during which the accumulated forces manifest themselves in conspicuous changes in physical geography and climate, and therefore in rapid movement in the march of evolution of organic forms, — periods when the forces of change are *potential*, and periods when they become *active*. Conformable rocks represent the intervals of comparative quiet, during which organic forms are either permanent or change slowly; unconformity represents a time of oscillation, with increase and decrease of land, and therefore of rapid changes of physical conditions and correspondingly rapid movement in evolution. The general unconformities, of

course, mark times of very general commotion, — of wide-spread changes of physical geography and climate, and consequently of exceptionally rapid and profound changes in organic forms.

These periods of revolution in all history are *critical*, and hence are of especial interest to the philosophic historian and to the evolutionist; but they are also in all history periods of *lost record*. And as in human so also in geological history, — the farther back we go the longer are the lost intervals and the more irrecoverable the lost records. We will now give examples of such lost intervals, and show their significance in evolution.

The first and by far the greatest of these is that which occurs between the Archæan and the Palæozoic. In every part of the earth where the contact has yet been observed the Primordial lies unconformably on the upturned and eroded edges of the Archæan strata. This relation was observed first in Canada, then in various parts of the Eastern United States, then in Scotland, the Hebrides, Bavaria, Bohemia, Scandinavia. Unconformity in such widely separated localities indicates wide-spread changes in physical geography, and therefore, presumably, of all those physical conditions included in the word *climate*. These changes of physical geography are best illustrated in the United States. The break between the Archæan and the Primordial has been observed in very many places all over the wide area of the United States, east and west: not only in Canada, in New York, in the Appalachian region, in Wisconsin, Missouri, Arkansas, and Texas, but also all over the Rocky Mountain region, in Nebraska, Montana, Idaho, Wyoming, Colorado, Utah, Nevada, New Mexico, and Arizona. As upturned, eroded, outcropping strata mean land surface, it is evident that there was at that time *a very large area or else several large areas of land* in the place now occupied by the American continent. In comparison with the subsequent Silurian it was *a continental period*. This land is often spoken of as *Archæan land*. It was indeed land of *Archæan rocks*, but for that very reason not of Archæan times, for these rocks were, of course, formed at the bottom of the sea in Archæan times, and therefore these localities were all seabed receiving sediment at that time. We know absolutely nothing of the land of Archæan times, and never can know anything until we find still older rocks, from the *débris* of which Archæan sediment was formed. The land spoken of above was *land of the Lost Interval*. That the interval was immensely long is evident from the prodigious erosion. That it was a period of wide-

spread oscillation is also apparent, for all the places mentioned were sea-bed in Archæan, land during the interval, and again sea-bed during the Silurian. But of this long interval not a leaf of record remains.

Evidently, then, at the end of the Archæan an enormous area of Archæan sea bottom was raised up and crumpled, and became land. After remaining land for a time sufficiently long to allow enormous erosion of crumpled strata it again went down to the old Primordial shore line, and the Silurian age commenced. This time of elevation is the lost interval.

Now, when the record closed in the Archæan, as far as we know, only the lowest forms of Protozoan life yet existed. The beginnings of life had not yet differentiated into what might be called a fauna and flora. When the record again opened with the Primordial we had already a varied and highly organized fauna, consisting of representatives of many classes and of all the great types of animal structure except vertebrates. Nor were these representatives the lowest in three several departments, for Trilobites and Orthoceratites can hardly be regarded as lower than the *middle of the animal scale* as it now exists. It is certain, therefore, that all the great departments except vertebrates, and most of the classes of these departments, including animals at least half-way up the animal scale, were differentiated during the lost interval. The amount of evolution during this interval cannot be estimated as less than all that has subsequently taken place. Measured by the amount of evolution, this lost interval is equal to all the history of the earth which has since elapsed. We escape this very improbable conclusion only by admitting *a more rapid rate of evolution during critical periods.*

It is one of the chief glories of American geology to have first established the Archæan as one of the primary divisions of time. It is even yet reluctantly admitted as such by many European geologists. And yet it is seen that from every point of view, whether of the rock system or of the life system, it is by far the most widely and trenchantly separated of all the eras.

The next greatest lost interval (though far less than the preceding) is that between the Palæozoic and the Mesozoic. Here we have the next most general unconformity, indicating the next most wide-spread changes of physical geography and climate, accompanied by the most sweeping changes in organic forms, not only in species and genera, but also in families and orders. This change is the more striking as it occurs in the midst of an abun-

dant life. It is the greatest and most general change in the forms of organisms which has ever occurred in the history of the earth. *It took place, again, during a lost interval.* A portion of the loss is recovered in the Permian, but the most critical time, the time of most rapid change, namely, that between the Permian and the Trias, is still missing. How we long to find the steps of this great change! What a flood of light would it shed on the process of evolution! But although the change in the organic kingdom was, just here, so enormously great, yet the lost interval does not seem very long, for in England the Trias and Permian seem to be conformable, though probably with change from marine to fresh-water conditions. It is hence impossible to resist the conclusion that the steps were just here fewer and longer and the progress more rapid than usual. As in human history, revolutions are the times of the birth of new social ideas, upon which, during the subsequent period of tranquillity, society is readjusted in prosperity and happiness on a higher plane, so also in geological history, critical periods are times of origin of new and higher organic forms, and the subsequent periods of tranquillity are times of readjustment of equilibrium and prosperous development of these forms.

Like the previous lost interval, this was also a period of oscillation,— a period of great increase of land, which was again partly submerged to inaugurate the Trias. It was, therefore, also *a continental period.* The land-making commenced at the end of the Coal period, in this country with the formation of the Appalachian Mountains, continued through the Permian, and culminated in the lost interval, which is, in fact, for that very reason lost.

Far less in length of time and perhaps in the sweeping character of the change of organisms, but far more important and interesting on account of the high position of the animals involved, is the lost interval between the Mesozoic and Cænozoic. The length of time lost here is comparatively small. In America, in many parts of the West, the uppermost Cretaceous seems to pass into the lowermost Tertiary without the slightest break of continuity. There may be some break, some unconformity, some lost record, but certainly it cannot be large. Yet the change, especially in the higher animals, is immense. In America the break and the lost interval is much greater between the Jurassic and Cretaceous than between the Cretaceous and Tertiary, still the organic change is far greater in the latter case. The reason is that the

changes of physical geography and climate in the latter were *more general.* Although in America the break and the lost interval is greater at the end of the Jurassic, yet, taking the strata all over the earth, the break is far more general at the end of the Cretaceous; and it is these *general* changes in physical geography which affect climate the most, and which, therefore, produce the profoundest changes in organic forms.

Now it is almost impossible to imagine a clearer proof of the fact of rapid evolution-movement during critical periods than we find in the shortness of the lost interval and the greatness of the change in higher organisms just at this horizon in the rocky series. Nothing can be more astonishing than the abundance, variety, and prodigious size of reptiles in America up to the very close of the Cretaceous, and the complete absence of all the grander and more characteristic forms in the lowest Tertiary, unless, indeed, it be the correlative fact of complete absence of mammals in the Cretaceous, and their appearance in great numbers and variety in the lowest Tertiary. If Cretaceous mammals existed in *America*, surely their remains would have been found in the wonderfully rich Cretaceous strata. It seems certain that in America, or at least in that portion which has been examined, mammals appeared somewhat suddenly and in great numbers on the scene, and were a principal agent in the extermination of the large reptiles. The wave of reptilian evolution had just risen to its crest, and perhaps was ready to break, when it was met and overwhelmed by the rising wave of mammalian evolution.

We have dwelt only on the great change in the higher classes, but the change really extended to all classes. This was, therefore, a time of exceptionally general and rapid changes in all departments alike. In other words it was a critical period in organic evolution.

That it was also a time of very extensive changes in physical geography here in America, as well as elsewhere, is well known. The Cretaceous sea, which extended from the Gulf of Mexico to the Arctic Ocean, covering the whole western plains and plateau region, and thus dividing the American continent into two, — an eastern Appalachian continent and a western or basin region continent, — was abolished at the end of the Cretaceous, and replaced by great fresh-water lakes in the same region, and the continents became one. Moreover, it is probable that it was a period of wide-spread oscillation, that is, of upheaval and again of subsidence to the condition of things found at the beginning of

the Tertiary. It is probable that the upheaval which destroyed the Cretaceous sea went much beyond the condition of things afterwards; that just at this interval the land was higher and larger than in the Tertiary; that, in short, this was again a *continental period*, and probably a period of greater cold than the subsequent Tertiary.

The change in physical geography, then, was immense, but in most places by bodily upheaval, not by crumpling of the strata; and therefore the usual sign of such change, namely, unconformity, is often wanting. The change of climate all over the American continent was no doubt very great, and the change in organic forms correspondingly great everywhere and in all departments; but this was especially true of all water-inhabiting species in the region of the old Cretaceous interior sea, for here there was a transition, not only in climate but from salt to fresh water through the intermediate condition of brackish water. The Cretaceous marine species rapidly disappeared, partly by extermination and partly by transmutation into fresh-water species, as has been observed, recently, to take place in some crustaceans under this change of conditions.[1] The Tertiary fresh-water species quickly appeared, partly by transmutation from the previous marine species and partly by transportation in various ways from other fresh-water lakes. But all this occurred in some places without the slightest break in the continuity of the strata.

The great change of climate and other physical conditions perhaps sufficiently explain the change in *invertebrate* species, but it is impossible to account for the somewhat sudden appearance of mammals in the lowest Tertiary, except by *migration* from other regions where they had existed in late Cretaceous times, having originated there by derivation in the usual way. That marsupials existed somewhere in Cretaceous times (though possibly not in America or Europe) there can be no doubt; for they lived, we know, in the preceding Jurassic and the following Tertiary, and they exist *now*. It is from these rather than from Cretaceous reptiles that Tertiary mammals were doubtless derived; and this derivation took place probably at rapid rate in the latest Cretaceous or during the lost interval, in some unknown locality, whence they migrated into the Tertiary lake region of the United States during the interval. This migration came most probably from Northern Asia, for it must be remembered that

[1] Arch. des Sciences, November, 1875, p. 284.

the interval was a continental period, and therefore probably a period of broad land connections between Nearctic and Palæarctic regions. The complete examination of the uppermost Cretaceous of different portions of Asia will probably reveal the immediate progenitors of the early Tertiary mammals of Europe and America. This introduces us to a most important element of rapid local faunal change, especially in higher animals, namely, *migrations*. If we do not dwell longer now on this, it is only because we shall have to recur to it again.

I have preferred, thus far, to speak of *general* evolution-changes of organisms, whether slow or rapid, as produced by varying pressure of external conditions, and of the most striking *local* changes by migrations from other regions, where the apparently suddenly-appearing species had previously existed, having originated there by evolution in the usual way. I have chosen, thus far, to represent the organic kingdom as lying, as it were, *passive* and plastic under the molding hands of the environment. I have done so because it is in accordance with true method to exhaust the more obvious causes of evolution before appealing to the more obscure and doubtful.

It is possible that general movements affecting alike all classes may be accounted for in this way alone. But there are many facts in the evolution of the organic kingdom, especially the sudden appearance of new forms in the quietest times, which can hardly be thus explained. There seem to be *internal* as well as *external* factors of evolution. Again, the internal factors may be either in the form of *tendencies* to change or of *resistance* to change. Of these, however, the latter seems to be most certain. There may be in the organic kingdom an "*inherent tendency*" to change in special directions, similar to that which directs the course of embryonic evolution, — a tendency, in the case of the organic kingdom, inherited from physical nature from which it sprang, as in the case of the embryo it is inherited from the organic kingdom through the line of ancestry. This cause, however, is too obscure, and I therefore pass it by.

But whether or not there be any such inherent tendency to change, there certainly is an inherent tendency to *stability*, — to persistence of organic form. If there be no inherent force of progress, there certainly is an inherent force of *conservation* greater in some species than in others. It seems probable that in many of the more rigid types this stability is so great, and therefore variation of offspring so slight, that progressive change of

form is too slow to keep pace with change of external conditions, especially in critical periods. If this be so, then an organism may be regarded as under the influence of two opposing forces: the one conservative, the other progressive; the one tending to equilibrium, the other to motion; the one to permanence, the other to change of form; the one static, the other dynamic; the one internal, *the law of heredity*, the other external, the *pressure of a changing environment*. Under the influence of two such forces, the one urging, the other resisting, it is evident that even with steady changes of external conditions the change of organic forms would be more or less paroxysmal. Other kinds of evolution, physical and social, evidently advance paroxysmally from this cause. As, therefore, in the gradual evolution of earth-features there are periods of comparative quiet, during which the forces of change are gathering strength but produce little visible effect, being resisted by crust-rigidity, and periods when the accumulating forces finally overcome resistance and determine comparatively rapid changes; as in social evolution there are periods in which forces of social change are gathering strength but make no visible sign, being resisted by social conservatism, — rigidity of the social crust, — and periods in which resistance gives way and rapid changes occur, so also in the evolution of the organic kingdom the forces of change, that is, pressure of changing environment, may accumulate but make little impression, being resisted by the *law of heredity* — of *like producing like* — or type-rigidity, until, finally, the resistance giving way, the organic form breaks into fantastic *sports* which are at once seized by natural selection, and rapid change is the result.

Some persons seem to think that paroxysmal evolution is inconsistent with the uniformity of nature's laws. On the contrary, it is in perfect accord. Laws and forces are indeed uniform, but phenomena are nearly always paroxysmal. The forces of volcanoes and earthquakes, of lightning and tempests, are uniform, but the phenomena are paroxysmal. Winds at the earth's surface, where the resistance is great, *blow in puffs*. A thin sheet of water over a smooth sloping surface *runs in waves*. The law may be illustrated in a thousand ways. In all cases where an accumulating force is opposed by a constant resistance, we have phenomena in paroxysms.

But whatever be the cause, the *fact* of paroxysmal movement of organic evolution is undoubted. All along the course of geological history, from beginning to end, even when the times were

quietest, where the record is fullest and apparently without any missing leaf, species come and go and others take their place, and yet only rarely do we find any transition steps. If this were merely once or twice or thrice, or to any extent exceptional, it might be explained by loss of record here and there, but it occurs thousands and tens of thousands of times. Now, if evolution moves only at uniform rate, if it takes one hundred thousand years to transmute one species into another (as it certainly does when evolution is moving at its usual rate), if there are at least one hundred thousand steps (represented each, of course, by a whole generation of many individuals) between every two consecutive species, it is simply incredible that all the individuals representing the intermediate steps, so infinitely more numerous than the species they connect, should be so generally, almost universally, lost. But the phenomena, as we find them, are easily understood if a few generations represent the transition step, and many generations the permanent form.

A similar rapid, almost sudden, appearance and extinction of *genera*, *families*, and higher groups at certain horizons are also common. In these cases the intermediate steps of transition are often found, and constitute, in fact, the chief demonstrative evidence of the truth of evolution. But the difficulty on the assumption of a uniform rate of evolution is none the less here, for the time required to evolve a new genus or a new family is, of course, immensely greater than in the case of a new species.

We will illustrate the difficulties of the ordinary view by one striking example. In the Upper Silurian, in the midst of a conformable series, — where if there be any break, any lost record, surely it must be very small, — appear suddenly, without premonition, *fishes;* not a connecting link between fishes and any form of invertebrates, but perfect, unmistakable fishes. Here we have, therefore, the appearance not only of a new class, but of a new sub-kingdom or type of structure, *Vertebrata*. Now, to change from any previously existing form of invertebrate, whether worm, crustacean, or mollusk, into a vertebrate, by a series of imperceptible steps represented by successive generations, — steps so imperceptible that it would take one hundred thousand of them to advance from one intermediate species to another, — would require an amount of time which is inconceivable to the human mind, and a number of steps, each be it remembered, represented by thousands of individuals, which can scarcely be expressed by figures. And yet we must believe that these innumerable tran-

sitional forms, each represented by innumerable individuals, are all lost, and that this prodigious time shows no evidence in the rocky record. If this case were exceptional we might possibly admit that fishes appeared in Great Britain by migration (as they probably did), but only after having previously existed untold millions of ages somewhere else; but similar cases are too common to be explained in this way.

Now the whole difficulty disappears, — we avoid the incredible imperfection of the geological record (imperfect at best); we avoid also the necessity of extending geological time to a degree which cannot be accepted by the physicist, — if we admit that the derivation of one species from another is not necessarily by innumerable imperceptible steps, but may sometimes be by a *few decided steps;* and that the same is true for the origin of new genera, families, orders, etc.; in a word, that there are in the history of evolution of species genera, families, orders, etc., and of the organic kingdom *periods of rapid movement.* When the whole organic kingdom is involved in the movement, then we call the period *critical*, and the record of it is often lost.

Thus, on the supposition of such rigidity or resistance to change in organic forms, varying in degree in different species and in different genera, families, orders, etc., a rigidity, also, *increasing by accumulated heredity so long as conditions remain unchanged*, it is evident that, in times of perfect tranquillity all species grow more and more rigid. In times of very gradual change the more plastic species change gradually *pari passu*, while the more rigid species change paroxysmally, now one, now another, as their resistance is overcome. Finally, in times of revolution nearly all forms yield to the pressure of external conditions and change rapidly, *only the very exceptionally rigid being able to pass over the interval to the next period of readjusted equilibrium.*

Thus, for example, the great and wide-spread changes of physical geography which occurred at the end of the Carboniferous, appropriately called in this country the *Appalachian revolution*, were the death-sentence of the long-continuing and therefore rigid Palæozoic types. But the sentence was not immediately executed. The Permian represents the time between the sentence and the execution, — the time during which the more rigid Palæozoic forms continued to linger out a painful existence in spite of changed and still changing conditions. But the most critical time — the time of most rapid change, the time of actual execution — was the *lost interval.* Only a very few most rigid forms pass over this interval into the Trias.

The Quaternary, a Critical Period. We have given examples of several general unconformities, the signs of wide-spread oscillations of the earth-crust, attended with increase and decrease of land, and therefore with great and wide-spread changes of climate and other physical conditions, and also with great and rapid changes of organic species. These times of general oscillation are therefore the natural boundaries of the Eras or primary divisions of Time. We have called them critical periods, transition periods, periods of revolution, because they are times of rapid change, both in the physical and the organic world, — a change overthrowing an *old* and establishing a *new* order of things. They are also times of *lost record.* We have seen that these critical periods, in comparison with the preceding and succeeding, are *continental periods*, and it is for this reason that their record is usually lost.

Now, the Quaternary is such a critical or transition period, marking the boundary between two great eras. The Quarternary is also a period of great and wide-spread oscillations, with increase and decrease of land, — a period of upheaval, erosion, down-sinking, to rise again slowly to the present condition. The early Quaternary was, therefore, to a marked degree a continental period. Here also we have newer rocks lying unconformably on the eroded edges of an older series — river sediments in old river-valleys, marine sediments in fiords; in other words, we have unconformity on a grand scale. Also, in connection with these oscillations, we have great changes in physical geography, and corresponding and very wide-spread changes in climate, and consequently corresponding rapid changes in organic forms. Here, then, we have all the characteristics of one of the boundaries between the primary divisions of time. We have a transition or *critical* period, — a period corresponding to one of the lost intervals; only in this instance, being so recent and being also less violent than the preceding ones, *it is not lost.* From this it follows that the study of the Quaternary ought to furnish the key which will unlock many of the mysteries which now trouble us. Some of the problems which have been or will be explained by study of the Quaternary we will now briefly mention.

I. *Changes of Species not sudden.* If the Quaternary were lost, and we compare the Tertiary rocks with the unconformably overlying recent rocks, and the Tertiary mammals with those now living, how great and apparently sudden seems the change!

How like to a violent extermination and re-creation! But the Quaternary is fortunately not lost, and we see that there has been no such wholesale extermination and re-creation, but only gradual though comparatively rapid transition.

II. *Migration One Chief Cause of Change.* But what is still more important, we are able to trace with something like certainty the cause of these rapid changes, and we find that in the higher animals, chief among these causes have been *migrations*, — migrations enforced by changes of climate, and migrations permitted by changes of physical geography opening gateways between regions previously separated by impassable barriers. This point is so important that we must dwell upon it. Only an outline, however, of some of these migrations and their effects on evolution can be given in the present condition of knowledge.

During Miocene times, as is well known, evergreens, allied to those now inhabiting Southern Europe, covered the whole of Europe as far north as Lapland and Spitzbergen. In America, Magnolias, Taxodiums, Libocedrus, and Sequoias very similar to, if not identical with, those now living on the Southern Atlantic and Gulf coasts and in California were abundant in Greenland. Evidently there could have been no *Polar ice-cap* at that time, and consequently no arctic species unless on mountain tops. During the latter part of the Pliocene the temperature did not differ much from the present; the Polar ice-cap had therefore commenced to form, with its accompaniment of arctic species. With the coming on of the *Glacial epoch*, the polar ice and arctic conditions crept slowly southward, pushing arctic species to Middle Europe and Middle United States, and sub-arctic species to the shores of the Mediterranean and the Gulf. With the return of more genial climate, arctic conditions went slowly northward again, and with them went arctic species slowly migrating, generation after generation, to their present arctic home.

Similarly, molluscous shells migrated slowly southward and again northward to their present position. But *plants* and some terrestrial invertebrates, such as *insects*, had an alternative which shells had not, namely, that of seeking arctic conditions also *upward* on the tops of mountains. Many did so, and were left stranded there until now. It is in this way that we account for the otherwise inexplicable fact that Alpine species in Middle Europe are similar or even largely identical with those in the United States, and also with those now living in arctic regions. These species were wide-spread all over Europe and the United

States in Glacial times; and while some of them afterward went northward to their present home, some in each country sought arctic conditions in Alpine isolation. This explanation, which has been long recognized for plants, has been recently applied by Mr. Grote to arctic insects found on the top of Mt. Washington and the mountains of Colorado.[1]

Undoubtedly changes of climate during this time enforced similar migrations among mammals also. But it is evident that while plants and invertebrates might endure such modifications of climate and such enforced migrations with little alteration of form, the more highly organized and sensitive mammalian species must be either destroyed or else must undergo more profound changes. Moreover, the opening of land connections between regions previously isolated by barriers would be far more quickly taken advantage of by mammals than by invertebrates and plants. The migrations of plants are of necessity very slow, that is, from generation to generation. The migrations of mammals, too, so far as they are *enforced* by changing climate, are of a similar kind; but the voluntary migrations of mammals, *permitted* by removal of barriers, may take place much more rapidly, even in a few generations. This introduces another element of very rapid local change, namely, the *invasion* of one fauna by another equally well adapted to the environment, and the struggle for life between the invaders and the autochthones.

For example: in America during the Glacial epoch, coincidently with the rigorous climate, there was an elevation of the continent, greatest in regions of high latitude, but also probably great along the line of the Mississippi River; for in this region it extended southward even to and beyond the shores of the Gulf. Professor Hilgard has shown that the elevation at the mouth of the Mississippi River was at least four hundred and fifty to five hundred feet above the present condition. Until the Glacial times the two Americas were certainly separated by sea in the region of the Isthmus, as shown by the Tertiary deposits there. This barrier was removed by upheaval during the Glacial epoch, and a far broader connection existed *then* than now. Through this open gate-way came the fauna of South America, especially the great Edentates, into North America. Similarly a broad connection then existed between America and Asia in the

[1] This application, with reference to Mt. Washington and other arctic insects in America, was previously made by Prof. A. S. Packard, Jr., in the Memoirs of the Boston Soc. Nat. Hist., i. p. 256. 1867. — Eds.

regions of the shallow sea between the Aleutian Isles and Behring Strait. Through this gate-way came an invasion from Asia, including probably the mammoth. With this invasion probably came also man. It seems probable, therefore, that the earliest remains of man in America will be found on the Pacific coast.

Also the great Pliocene lake, which stretched from near the shores of the Gulf far into British America, and possibly into arctic regions, and formed a more or less complete barrier to the mammalian fauna east and west, *was abolished* by upheaval, and free communication was established. It is impossible that all these changes of climate and all these migrations, partly enforced by changes of climate and partly permitted by removal of barriers, and in this latter case especially attended with the fiercest struggle for life, should not produce rapid and profound changes in the mammalian fauna.

In Europe the process has been more accurately studied and is better known. In Quaternary times at least four different mammalian faunæ struggled for mastery on European soil. (1.) The Pliocene autochthones. (2.) Invasions from Africa by opening of gate-ways through the Mediterranean: one by way of Italy, Sicily, and Malta, and one by Gibraltar, both of which have been again closed. (3.) Invasions from Asia, by removal of a great sea barrier connecting the Black and Caspian seas with the Arctic Ocean. This gate-way has remained open ever since. (4.) Invasions from arctic regions, enforced by changes of climate. Probably more than one such invasion took place; certainly, one occurred during the second Glacial epoch. The final result of all these climatic changes and these struggles for mastery was that the Pliocene autocthones, adapted to a more genial climate, were mostly destroyed or else driven southward with some change into Africa: the African invaders were driven back also into Africa, and with some Pliocene autocthones isolated there by subsidence in the Mediterranean region closing the southern gate-ways, and still exist there under slightly modified forms; the Arctic invaders were again driven northward by return of more genial climate, and there exist to this day; while the Asiatics remained masters of the field, though greatly modified by the conflict. Or perhaps, more accurately, we might say that the existing European mammalian fauna is a resultant of all these factors, but the controlling factor is the Asiatic. With the Asiatic invasion came man, and was a prime agent in determining the final result.

Thus, regarding the Tertiary and the Present as consecutive eras, and the Quaternary as the transition or critical period between, then, if the record of this period had been lost, corresponding with the unconformity here found, we should have had here an enormous and apparently sudden change of mammalian species. Yet this change of fauna, as great as it is, is not to be compared with that which occurred between the Archæan and Palæozoic, or between the Palæozoic and Mesozoic, or even that between the Mesozoic and Cænozoic; for the change during the Quaternary is mostly confined to species of the higher mammals, while the change during previous critical periods extended to species of all grades, and not only to species, but to genera, families, and even orders. We conclude, therefore, that *the previous critical periods or lost intervals were far longer than the whole Quaternary; or else that the rate of evolution was far more rapid in these earlier times.*

To sum up, then, in a few words, the general formal laws of evolution-change throughout the whole history of the earth: —

(1.) Gradual, very slow changes of form everywhere under the influence of all the factors of change, known and unknown: for example, pressure of changing physical conditions whether *modifying the individual* (certainly one factor), or *selecting the fittest offspring* (certainly another factor); improvement of organs by use and the improvement inherited (certainly a third factor), and perhaps still other factors yet unknown. This general evolution by itself considered would produce similar changes everywhere, and therefore would produce geological faunæ, but not geographical diversity. Determination of a geological horizon would in this case be easy, because fossil species would be everywhere identical.

(2.) Changes in different places and under different physical conditions, taking different directions and advancing at different rates, give rise to *geographical faunæ*. This, if there were nothing more, would produce far greater geographical diversity and more complete localization of faunæ and floræ than now exists, — so great that the determination of a geological horizon would be impossible.

(3.) The force of change resisted by heredity, in some species and genera more than in others, determines paroxysms of more rapid movement of general evolution, affecting sometimes species, sometimes genera or families. The sudden appearance of species, genera, families, etc., in quiet times is thus accounted for.

(4.) *During critical periods*, oscillations of the crust, with rapid changes of physical geography and climate, determine a more rapid rate of change in all forms: first, by *greater pressure of physical conditions;* and, second, by *migrations* partly enforced by the changes of climate and partly permitted by removal of barriers, and the consequent *invasion* of one fauna and flora by another and *severe struggle* for mastery. This would tend to *equalize again* the extreme diversity caused by the second law; but the effect would be more marked in the case of animals than plants, because voluntary migrations are possible only in this kingdom. Hence it follows that *a geological horizon is far better determined by the fauna than by the flora.*

III. *Historic Value of the Present Time.* Most geologists regard the Present as one of the minor subdivisions of the Cænozoic era, or even of the Quaternary period. More commonly the Quaternary and Present are united as one age — the age of man — of the Cænozoic era. The Cænozoic is thus divided into two ages: the age of mammals commencing with the Tertiary, and the age of man commencing with the Quaternary; and the Quaternary subdivided into several epochs, the last of which is the Present or Recent. But if the views above expressed in regard to critical periods be correct, then the Present ought not to be connected with the Quaternary as one age, nor even with the Cænozoic as one era, but is itself justly entitled to rank as one of the *primary divisions* of time, as one of the great eras separated like all the other eras by a critical period; less distinct it may be, at least as yet, in species than the others, the inaugurating change less profound, the interval less long, but dignified by the appearance of man as the dominant agent of change, and therefore well entitled to the name *Psychozoic* sometimes given it. The geological importance of the appearance of man is not due only or chiefly to his transcendent dignity, but to his importance as an agent which has already very greatly, and must hereafter still more profoundly, modify the whole fauna and flora of the earth. It is true that man first appeared in the Quaternary, but he had not yet established his supremacy; he was still fighting for mastery. With the establishment of his supremacy the reign of man commenced. An age is properly characterized by the *culmination*, not the first appearance, of a dominant class. As fishes existed before the age of fishes, reptiles before the age of reptiles, and mammals before the age of mammals, so man also appeared before the age of man.

We therefore regard the Cænozoic and Psychozoic as two consecutive eras, and the Quaternary as the critical, revolutionary, or transitional period between. But since the record of this last critical period is not lost, and we must place it somewhere, it seems best to place it with the Cænozoic era and the mammalian age, and to commence the Psychozoic era and age of man with the completed supremacy of man, that is, with the Present epoch.

BERKELEY, CALIFORNIA, *March* 15, 1877.

RECENT LITERATURE.

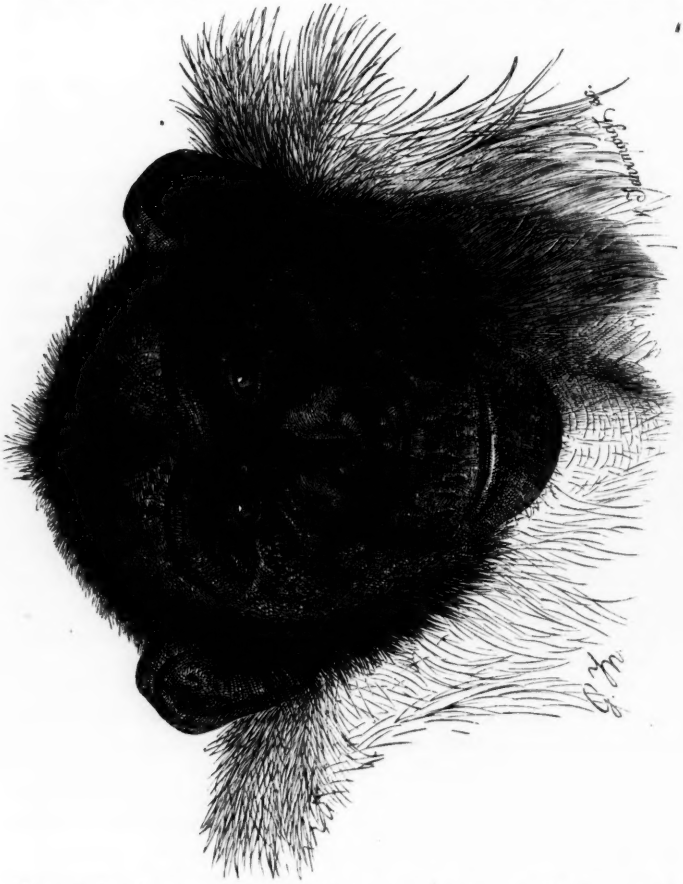
BREHM'S ANIMAL LIFE.[1] — A second edition of Brehm's well-known German work on the animal kingdom is now in course of publication, to be issued in about a hundred parts, published weekly or fortnightly, forming a series of volumes of unusual attractiveness and interest. The author tells us that it is really a new work under an old title, having been rewritten and enlarged. While the first volume of the first series treats of the mammals from the apes down to the family of dogs, succeeding volumes will treat of the other mammals and of the reptiles and fishes. These will be written by Dr. A. E. Brehm, the well-known naturalist, while those on the articulated animals will be written by Prof. E. L. Taschenberg, of Halle, and the mollusks will be treated of by Prof. Oscar Schmidt, of Strasburg. What provision is to be made for the other invertebrate animals is not yet announced.

The work is of a general nature, not designed for the special zoölogical student or for children, but for those who wish to gain a knowledge of the principal forms of animal life, their habits and distribution. There are no troublesome, perplexing anatomical or embryological details, save wood-cuts of skeletons, in word or picture, no foot-notes, and the style is easy, sprightly, and often colloquial. It is apparently a popular work in the best sense of the word, and should be well patronized in this country, if for no other reason than for the wealth of wood-cuts, both full-page and textual, which alone, to those ignorant of German, would make it of lasting value. The illustrations are nearly all new to us, and in very many, we suppose most, cases are drawn from life by such artists as R. Kretschmer, G. Mutzel, and E. Schmidt, with the greatest apparent fidelity.

The plan of the work is excellent. After an introductory chapter on life in its totality, the apes are described, — man, the type of the first suborder of Primates, being referred to only incidentally in comparison with

[1] *Brehm's Thierleben.* Allgemeine Kund, des Thierreichs. Grosse Ausgabe. Zweite umgearbeitete und vermehrte Auflage. Erste Abtheilung, Säugethiere. Erster Band. Leipzig Verlag des bibliographischen Institute. 1876. 8vo, pp. 706. New York: B. Westermann & Co. 40 cents a part; 12 parts to a volume.

the apes, which represent the second suborder of Primates. Then follows a general "popular" account of the forms of apes, their geographical distribution, dwelling-places, food, motions, social life, language, reproduction, education, rearing of young, diseases, life in confinement, and of the apes figured on the Egyptian temples; then succeeds a more special account of the gorilla, the chimpanzee, and the tschego (*Anthropopi-*



(Fig. 59.) TSCHEGO APE.

thecus tschego), and orang, with the lower forms. In this comprehensive and, we may readily believe from the high reputation of the author, thorough manner, the different groups of animals are treated. A sample of the elaborate nature of the wood-cuts is afforded in the two accompanying views of the head of a five-year old tschego in the Dresden Zoological Garden, which was brought from the Loango coast.

As an indication of the abundance of illustrations in the first volume it may be stated that there are nineteen full-page pictures of animals, grouped from studies after nature; fifty-two finished cuts in the text of apes and monkeys; twelve of bats; twenty-eight of cats; and thirty-eight of dogs. A volume on insects has appeared, and the second volume on mammals is now in course of publication.

(Fig. 96.) TSCHEGO APE. Profile.

United States Commission of Fish and Fisheries.[1] — From a comparatively small beginning the United States Commission of Fish and Fisheries has, by its practical results in pisciculture, assumed so much importance that Congress last spring appropriated fifty thousand dollars for the work of 1877. It is understood that this appropriation is to be devoted solely to the raising of fish, and not for any purely scientific investigations, although by the excellent economical management of Professor Baird and his assistants in past years a great deal has been

[1] *United States Commission of Fish and Fisheries.* Part III. Report of the Commissioner for 1873–74 and 1874–75. Washington. 1876. 8vo, pp. 777.

done, by their gratuitous labors, to extend the knowledge of such marine and fresh-water animals of the United States as form the food of fishes. The present report is wholly practical in its nature, comprising an inquiry into the decrease of the food fishes, and the propagation of food fishes in the waters of the United States. Appended to the report are essays, mostly taken from foreign sources, on fisheries and fish culture in the Old World. These essays are very suggestive, and it is to be expected that the results of experiments and studies made by the present commission will lead to discoveries and records of equal value, should the commission be maintained by the government for a sufficient number of years.

HYATT'S NORTH AMERICAN SPONGES.[1] — The second part of this elaborate revision of our North American sponges contains a good many novel and interesting facts regarding the influence of temperature and the nature of the sea-bottom upon the growth, variation, and distribution of our useful sponges, as well as the mode of fishing for and preparing them for the market. Professor Hyatt regards the sponges as forming "a distinct sub-kingdom or branch of animals, equivalent structurally to the Vertebrata or any of the larger divisions which are characterized by the most important structural differences." The excellence of the plates shows how well photography may be applied to the delineation of these animals.

RECENT BOOKS AND PAMPHLETS. — Reconciliation of Science and Religion. By Alexander Winchell, LL. D. New York: Harper and Brothers. 1877. 12mo, pp. 403.

Proceedings of the Davenport Academy of Natural Sciences. Vol. ii., Part I. January, 1876–June, 1877. Davenport, Iowa, July. 1877. 8vo, pp. 148. 3 plates.

Account of the Discovery of Inscribed Tablets. By Rev. J. Gass. With a Description by Dr. R. J. Farquharson. (Proceedings of the Davenport Academy of Natural Sciences, vol. ii.) Davenport, Iowa, July, 1877. 8vo, pp. 23. 3 plates.

List of the Vertebrated Animals now or lately living in the Gardens of the Zoological Society of London. Sixth Edition. London. 1877. 8vo, pp. 519, with cuts.

Zur Morphologie des Tracheensystems. Von Dr. J. A. Palmén. Helsingfors. 1877. 8vo, pp. 149. 2 plates.

Annual Report of the Entomological Society of the Province of Ontario for the year 1876. Toronto. 1877. 8vo, pp. 58.

On the Dispersal of Non-Migratory Insects by Atmospheric Agencies. By Albert Müller (Basileensis). (Reprinted from Trans. Ent. Soc. Lond. 1871.) Basle. 1877. 8vo, pp. 16.

Report of the Director of the Central Park Menagerie, Department of Public Parks, City of New York, for year 1876. New York. 1877. 8vo, pp. 34.

Bathybius und die Moneren. Von Ernst Haeckel. 8vo, pp. 12. 1877.

Brehm's Thierleben. Bd. 2. Heft i.–iv. Leipzig. 1877. New York: B. Westermann & Co. 40 cents a Heft.

De for Ager, Eng, og Have skadeligste Insekter og Smaakryb. Af W. M. Schoyen. Kristiania, 1875. 12mo, pp. 212. 8 plates.

[1] *Revision of the North American Poriferæ.* With Remarks upon Foreign Species. Part II. (Memoirs of the Boston Society of Natural History, vol. ii., Part IV., No. 5. Boston, May 28, 1877. 4to, pp. 73. 3 carbon photographs.

De i Husene skadeligste Insekter og Midder, der angribe og bedœrve vore Madvarer, Klœder, Bohave og svrige Eiendele under Tag. Af W. M. Schoyen. Kristiania, 1876. 12mo, pp. 102. 3 plates.

Enumeratio Insectorum Norvegicorum. Fasciculum III. Catalogum Lepidopterorum Continentem. Auctore H. Siebke defuncto, edidit J. Sparre Schneider. Christiania, 1876. 8vo, pp. 188.

Enumeratio Insectorum Norvegicorum. Fasciculum IV. Catalogum Dipterorum Continentem. Auctore H. Siebke defuncto, edidit J. Sparre Schneider. Christiania, 1877. 8vo, pp. 255.

Some Remarkable Gravel Ridges in the Merrimac Valley. (Abstract.) By George F. Wright. (From the Proceedings of the Boston Society of Natural History, vol. xix.)

I. On the Brains of some Fish-Like Vertebrates. II. On the Serrated Appendages of the Throat of Amia. III. On the Tail of Amia. By Burt G. Wilder. 1876. 8vo, pp. 10, with a plate. (From the Proc. Am. Ass. Adv. Sci. Buffalo Meeting, August, 1876.)

GENERAL NOTES.

BOTANY.[1]

VIOLETS. — Most of our readers are aware that many species of violets have, in summer, flowers which are totally unlike the showy, attractive blossoms of early spring; for instance, the lance-leaved violet and the arrow-leaved violet bear late, inconspicuous flowers, in which the petals are reduced to the merest rudiments, and only two or three stamens with pollen are present. Flowers of this sort have long been known, but they need to be more carefully examined with reference to their specific peculiarities. It is proposed to give in this note a preliminary sketch of the literature of the subject, in the hope that some of our botanists may collect and study the forms here referred to. Dillenius, in 1732, (Hort. Eltham, 408) observed that *Viola mirabilis* has flowers of two kinds: the spring flowers, with well-developed corolla and stamens seldom produce fruit, but the later flowers, in which he found stamens and no petals, always do. Linnæus (Semina Muscorum Detecta, 1732) refers to *Viola mirabilis* as one of the plants which had been thought to bear fruit without any antecedent blossoms; but he states that in the case of this plant, as in others referred to, blossoms with good stamens and pistils are present. It is said by Dr. Oliver that in a later work Linnæus remarks of *Viola mirabilis* that "the early flowers provided with a corolla are often barren, while others, appearing subsequently, and destitute of a corolla, are fertile."

Conrad Sprengel (1793) refers to *Viola mirabilis* as bearing two kinds of flowers, but states that he had not had an opportunity of examining the plant.

In 1823, De Gingins, in his Mémoire sur la Famille des Violacées, page 11, writes that "most of the species of the section of violets properly so-called have the singular property of sometimes producing incomplete

[1] Conducted by PROF. G. L. GOODALE.

flowers more or less destitute of a corolla; their fruits are nevertheless as perfect as, or even more perfect than, those which follow complete flowers. This phenomenon is observed frequently in autumn at the second blooming of violets; and the exotic species transplanted to our gardens have, under unfavorable conditions, apetalous flowers with deformed essential organs, which nevertheless bear perfect fruit."

From Dr. Oliver's review, previously referred to, we take the following notice of a work to which we do not have present access. M. Monnier, of Nancy (Guillemin's Archives de Botanique, 1833), says that none of the early spring flowers of *Viola hirta* bear fruit. "After the first flowering the leaves take on a further development: they become hairy, and bear in their axils flowers destitute of a corolla and with the five stamens almost always distinct and shorter than the ovary. The peduncles bearing these flowers curve downwards and bury the ovaries under the surface of the soil, where the seeds are ripened."

In a review given at second hand in *Botanische Zeitung* for November, 1854, are some quotations from a memoir by Timbal-Lagrave (On the Genus Viola, 1853): "It is the custom in botany to examine a plant when it is grown, that is, when it has completed its development or has reached the climax of its vegetation and is in flower. This usage, well enough for most cases, is faulty when it is applied to the section *Nominium* of *Viola*. It has here led botanists into errors and doubts, which have rendered the study of this section a matter of great difficulty. The period of early blossoms in *Viola* is the *youth* of the plant; its old age is another epoch in its development which was unknown to the older botanists, and herein lies the ground of the difficulties. . . . . In the stemless violets the following facts can be observed: in early spring a few leaves appear, and these develop until April; then come the blossoms with richly colored petals, and often with some fragrance, but these flowers, although provided with essential organs, are infertile. At first I believed that this anomaly is dependent on some modification of the stigma, or caused by some atmospheric influence, but I am now convinced that it arises from the lack of pollen in the anthers; fertilization cannot take place; the flower soon fades, dries up, or decays without any result.

"In this period, which I call youth, a new growth takes place: from the cluster of persistent radical leaves accompanying the first flowers new leaves arise, which soon become large and acquire firmness, having even larger and stiffer hairs. Towards the end of May and June new flowers come up, but they are very different from the first. In some species the blossoms have no petals, in others only one or two, but these are always inclosed in the calyx and are frequently the merest rudiments. The whole floral apparatus is modified, and yet fertilization takes place. . . . . A comparative study of the different organs of the first and second flowers of these plants, the growth or the abortion of this or that part, the position, the duration, and the functions, afford many essential characters

which, added to those already known, will aid in the study of this genus."

In *Botanische Zeitung* for October, 1857, Daniel Müller, of Upsal, gives an instructive account and a few figures of the incomplete flowers of certain violets. He states that the anthers contained only a few grains, which did not seem to him like perfect pollen, but rather like minute ovules. In spite of a whimsical theory with which he closes his paper, the account must be valued for the accurate descriptions of the incomplete flowers of several species.

A very interesting paper on this subject was read in July, 1860, before the Botanical Society of France, by M. Eugène Michelet. The statements made by him agree essentially with those just given.

In 1863, Von Mohl (in *Botanische Zeitung*) gives an abstract of the literature relating to cleistogamic flowers, and presents some instructive results of his own observations, of which the following is an abstract: "The process of fertilization in *Viola elatior* F. was more easily investigated than in the other species examined. In this species, as in all apetalous violets, the style is short and hooked, and in immediate contact with the anthers with which it alternates. Besides these two stamens which in this plant I always found developed, I discovered in some flowers one or two more. Although the anther cells are only one seventh to one sixth of an inch long, they have a number of pollen grains. The greater part of these push forth pollen tubes even while they are still in the anther, and these tubes pass out of the upper end of the anther cells, in thick strings, directly to the contiguous stigma. If the stamens in a fresh flower are drawn away from the stigma, the tubes will not break, but the pollen grains will be released from the opened anther cell, so that the latter will be left empty. On tearing away the anthers, some pollen grains which have not pushed out any tubes will fall out from them. It appears to me questionable whether without such a mechanical process pollination from these would take place; at least I have not observed any such case. With the drying of the anthers after fertilization, the tubes in their course from the anthers to the stigma dry up also, and then break off when the anthers separate, without withdrawing the pollen grains which are there held fast. Similar appearances are presented by the anthers in *Viola canina*, which touch the stigma. Besides this, it is seen that from those anthers, which in this species are always turned away from the stigma, pollen tubes start out and pass down in a serpentine course over the upper part of the ovary and the back and sides of the style. This observation is easily made by means of a Lieberkühn illuminating mirror. In this species, also, I frequently found pollen grains which had fallen out of the anthers, but I am not sure whether this discharge takes place naturally; for if we examine anthers which have become dry after fertilization, and on which, therefore, while fresh no force could have been exerted, they will be found

thickly filled with pollen grains. These are colorless, finely dotted, and thin-walled, and they wrinkle up when drying.

"The pollen grains of *Viola mirabilis* fall out from the anthers more easily and in greater abundance, and this may be regarded as of regular occurrence. The number of pollen tubes which run from the anthers to the stigmas is far smaller than in the other species spoken of, and the anthers are not so finely fastened on the stigma. Here, too, a part of the pollen will be pulled out by its tubes when the anthers are detached." Von Mohl closes this part of the memoir by stating that, owing to the changes which the pollen of the late flowers undergo in drying, or on access of water, it has been impracticable to compare the pollen of the early large blossoms with that of the late, inconspicuous ones. He further states that in these late flowers fertilization by the pollen of any other flower is of course an impossibility.

It may here be said that, as Timbal-Lagrave suggests, the characters of the late flowers of violets can be of aid in distinguishing species. Koch in his Synopsis has a section headed Flores Seriores Apetali, Later Blossoms without Petals. We do not know of any attempts other than those mentioned above to separate species by means of these peculiarities.

In Kuhn's Memoir, in *Botanische Zeitung* for 1867, a list of forty-four cleistogamic flowers is given, in which *Viola* is mentioned.

Lastly, in Mr. Darwin's new work, Forms of Flowers, 1877, the whole subject has received most careful attention.

Silphium Laciniatum. — Sections of fresh leaves of *Silphium laciniatum*, the compass plant, show that the parenchyma is composed of "palisade tissue," that is, of the tissue which occurs only immediately beneath the upper surface in most leaves.

Not only are both upper and under surfaces provided with the tissue usually regarded as peculiar to the upper portion of the leaf, but the whole of the leaf pulp from one surface to the other is also composed of it. There are often as many as six closely packed layers of palisade cells. — C. E. Bessey.

Sarracenia Variolaris. — The experiments referred to in the June number of the Naturalist have been repeated by me several times of late, and with uniform results. At the last meeting of the Botanical Section of the Boston Society of Natural History the experiments were again tried in the presence of the members. The results agreed perfectly with those detailed by Dr. Mellichamp. — B. M. Watson, Jr.

Botanical Papers in Recent Periodicals. — *Flora*, No. 16. E. Pfitzer, Observations in Regard to the Structure and Development of Epiphytic Orchids (dealing with the peculiar long cells in the tissue of *Ærides*, and with the occurrence of silicious discs in the pseudo-bulbs of epiphytic orchids, continued in No. 17). Gandoger, New Roses from Southeastern France. No. 17. Dr. Carl Kraus, Causes of the Unver-

tical Direction of Growth of Shoots. Schulzer, Mycological Notes. No. 18. Dr. Oskar Drude, *Agrostis tarda*, a New Species in the Flora of the Alps. F. Arnold, Lichenological Notes. J. B. Kreuzpointner, Notice in regard to the Flora of Munich.

Botanische Zeitung, No. 26. Prof. Schenk, A Contribution to our Knowledge of the Structure of the Fruits of *Compositæ* and *Labiatæ*. Reports of Societies. No. 27. Christoph Gobi, On a Mode of Growth of the Thallus of *Phæosporeæ*. Dr. Wilh. Jul. Behrens, The Flowers of Gramineæ. Celakovsky, The Theory of the Ovule. Reports of Societies. Nos. 28 and 29. J. Reinke, Remarks in Regard to the Growth at the *Punctum Vegetationis* of *Dictyodaceæ* and *Fucaceæ*. Reports of Societies.

ZOÖLOGY.[1]

Rare Snakes from Florida. — Mrs. A. D. Lungren, of Volusia, has made collections in natural history which have added a number of facts of interest to the herpetology of Florida. She has obtained the *Contia pygæa*, a calamarian form, of which but two specimens are known, both from Volusia. The second specimen of *Dromicus flavilatus* comes from her collections. It will be remembered that the first specimen of this rare species was procured by Dr. H. C. Yarrow, on the coast of North Carolina, at Fort Macon. She has also found the *Helicops Allenii* in the same neighborhood, and a new species of *Chorophilus* (*C. verrucosus* Cope). Persons desiring collections from that region, in any department of natural history, cannot do better than communicate with her. — E. D. C.

Red-Bellied Nut-Hatch (Sitta Canadensis) nesting on the Ground (?). — On the 27th of May the son of a neighbor brought me four eggs from a nest he discovered in the woods, stating that it was built in a hole in the ground, and that he found it by the old bird's leaving it and attempting to lead him away by the well-known artifices of many ground-building birds. The nest contained six eggs, white, with a faint blush, well covered, especially at the larger end, with coarse reddish-brown spots, mingled with a few faint lilac ones. While he was removing the eggs the bird was very courageous, and seemed much inclined to attack him, but when frightened away alighted on the side of a tree, up which she ran "like a woodpecker." He described the bird as follows: In size, quite small; color of back, blue; of breast and under parts, reddish-brown, a very little white on it, and quite a long bill. As this description was volunteered without any questioning on my part, I think it must be quite correct; and, taken with the climbing habits of the bird, I can think of no bird which it can indicate but the red-bellied nut-hatch, though I have never known that bird to be described as nesting elsewhere than in a tree or stump. The eggs meas-

[1] The departments of Ornithology and Mammalogy are conducted by Dr. Elliott Coues, U. S. A.

ured .65X.55, and were quite fresh. The next morning I visited the nest, hoping to see the bird and obtain the remaining eggs, but they had been removed, probably by the old bird, as the nest was unknown to other persons. The nest was built about a foot from the base of a pine amongst a clump of those trees, and was about two inches in diameter and four in depth, going down through the pine needles to the ground; and on a few of the needles the eggs were laid. If I am right in my conclusions as to the species, I think that this case must be quite unique both in locality and method of nesting. — FRANK H. NUTTER, West Roxbury, Mass.

ON A TRANSITORY FŒTAL STRUCTURE IN THE EMBRYOS OF SERPENTS AND LIZARDS.[1] — In the prosecution of his studies in biology the student cannot fail frequently to meet with structures and organs destined to have but a transient existence. A closer insight into the nature of these cases reveals the fact that they are naturally divisible into two groups. In one group, these structures, although very transient in their duration, subserve, while they exist, important functions, and are often quite indispensable to the development of the embryo. In the other group the most rigorous investigation fails to detect any purpose connected with the life of the subject for which they were called into existence. They serve only as illustrations of a general plan of development. Such are the rudimentary teeth developed in the jaw of the whalebone whale (*Balæna mysticetus*) prior to the appearance of baleen plates or permanent teeth, and corresponding rudimentary incisive teeth in the upper jaw of the Ruminantia, which are never followed by teeth having any functional character.

To the former group belong all those obvious and essential structures in the development-history of the mammalia, including also a few whose function seems so simple and transient, yet often important, as to be frequently overlooked. It is to one of the latter class to which we wish to draw the attention of the society.

It is a fact well known even to common observation that at the end of the beak of the fœtal chick there exists a sharp process or horn which is evidently employed instinctively to break the brittle shell of the egg when the chick has arrived at fœtal maturity. A very similar structure is found on the beak of some of the embryo turtles; at least in the genus *Emysaurus* in that group of reptiles. In both birds and reptiles it disappears soon after exclusion from the egg.

Somewhat recently, Dr. Weinland, of Germany, claims to have discovered in all the snakes of that country, and in many lizards, that a small, sharp tooth is developed in the premaxillary bone of the upper jaw designed to cut and tear the tough egg membrane that surrounds the fœtus, and thus furnish important aid in its liberation. This observation of Dr. Weinland is quoted by Owen in the last edition of his great

[1] Presented to the Ann Arbor Scientific Society, July, 1876.

work on Comparative Anatomy, and also by Agassiz in his Contributions to the Natural History of the United States, and by both writers with acceptance, but without personal verification. My observations, which have been made upon embryos of several genera and species of serpents and lizards of this country, have not enabled me to confirm the observations of Dr. Weinland; on the contrary, I feel quite sure that no such structures exist in the fœtuses of the genera *Eutænia* and *Storeria* among our snakes, nor in the fœtus of the genus *Scincus* among lizards. But without expressing a doubt about the correctness of the observations of Dr. Weinland, I am compelled upon the basis of my own researches to call in question the universality of the rule; and as the indorsement of Professors Owen and Agassiz is without personal verification, I cannot regard them as having any positive value in the decision of such a question. — A. Sager.

ANTHROPOLOGY.

Anthropological News. — *Erganzungsheft* 50 of Petermann's *Mittheilungen* contains E. de Pruyssenaere's account of his journeys and discoveries in the region of the White and the Blue Nile. The seventh chapter (pp. 18–27), relates to the population of the Upper White Nile, and especially to the Dengas.

Murray issues a volume entitled, The Cradle of the Blue Nile; A Visit to the Court of King John of Ethiopia, by E. A. de Cosson.

In *Nature*, April 26th, is a lengthy review of a paper on the races and tribes of the Chad Basin, in *Zeitschrift der Gesellschaft für Erdkunde*, by Dr. G. Nachtigall.

We have received from the author, W. L. Distant, two pamphlets, reprints from the *Journal of the Anthropological Institute*, entitled respectively, On the Term Religion as used in Anthropology; and, Our Knowledge of the Nicobarians. The same gentleman exhibited to the Institute, April 24th, photographs of the people of the Andaman and Malacca islands.

The Journal of the Victoria Institute, vol. x., just issued, contains some valuable articles reviewing the grounds of modern speculations, especially in England.

Nos. 3 and 4 of *Matériaux* appear together. The principal communication of importance to students, outside of France, is that of M. Ernest Chantre, describing the collections of bronze implements exhibited at the last meeting of the Congress of Prehistoric Archæology, held during the past summer at Buda Pesth.

The Russian Geographical Society will publish a description of the upper part of the Oxus, of the Hindoo Koosh, and of the Western Himalayas. The work will be accompanied by ethnographical maps and vocabularies.

In *The Academy* for April 21st and 28th, Mr. Percy Gardiner reviews

at length the discoveries of Dr. Schliemann, at Mycenæ. He concludes that the supposed analogy of the treasures to Byzantine work is delusive, and that they are of a very early date.

In *Popular Science Monthly* for June, Herbert Spencer writes on The Evolution of the Family, and Prof. Wm. B. Carpenter on Mesmerism-Odylism, Table Turning, and Spiritualism.

In the *Atlantic Monthly* for May, Mr. Edward H. Knight begins a series of illustrated articles on Crude and Curious Inventions at the Centennial Exhibition, commencing with musical instruments.

The *Nineteenth Century* for June contains an article on Infanticide, by C. A. Tyffe.

Dr. Dalrymple, of Baltimore, sends us an interesting pamphlet entitled, Excerpta ex Diversis Litteris Missionariorum, issued during the first part of the present year.

In the Transactions of the Wisconsin Academy of Science, etc., vol. iii. 1875–1876, the following archæological papers appear: The Ancient Civilization of America, by W. L. J. Nicodemus; Copper Tools found in the State of Wisconsin, by J. D. Butler; Report of the Committee on Exploration of Indian Mounds in the Vicinity of Madison.

Dr. Gustav Bruhl has sent to the Smithsonian Institution four pamphlets, printed in German, on Die Culturvölker Alt Amerikas, treating of the Mississippi Valley, Mexico, Chiapas and Yucatan, and Central America.

An article in the *Church Gazette*, x., No. 4, New York, treats of the Proto-Historic Settlement of America.

Prof. J. Hammond Trumbull sends to the *Magazine of American History*, June, a note on the Indian names of places on Long Island, derived from esculent and medicinal roots.

Before the Anthropological Institute of London, April 24th, three papers were read on American subjects: On the Migrations of the Eskimo, by Dr. John Rae; On Earthworks in Ohio, by Robert B. Holt; Note on Skulls from Ohio, by Prof. Geo. Busk.

The Annual Report of the Commissioner of Indian Affairs and that of the Board of Commissioners must not be overlooked in the summary of contributions to American ethnology. The map of the location of tribes in the former is especially valuable. — Otis T. Mason.

GEOLOGY AND PALÆONTOLOGY.

Pan-Ice Work and Glacial Marks in Labrador. — In an article in the *Canadian Naturalist* (viii. No. 4), entitled Notes on some Geological Features of the Northeastern Coast of Labrador, Prof. H. Y. Hind describes the action of pan-ice in abrading and polishing the rocks both above and below the sea level. He gives an account of the mode of formation of the remarkable gneiss steps or terraces in Tooktoosner Bay, south of Hopedale, and in Lake Melville, Hamilton Inlet. His

observations fully supplement and corroborate the writer's[1] statements made ten years ago in a paper which Mr. Hind has evidently overlooked. Mr. Hind personally traced this action of shore ice to an altitude of six hundred feet above the ocean, — we had at a rough estimate put the height of these rock terraces at five hundred feet above the sea, — and concluded that the action of the shore ice reached the height of one thousand feet (p. 222), a conclusion independently formed by Mr. Hind (*Can. Nat.*, p. 231), as he remarks that "erratics and local rounded fragments of rock are not numerous until a height exceeding one thousand feet is attained, and even then, except perhaps in hollows, which I had no opportunity of examining, bowlders and perched rocks are very much less numerous than at greater elevations in the far interior, where I saw them in countless multitudes in 1861." We differ, however, from Mr. Hind in considering that this work of abrasion is performed rather in the autumn, winter, and especially in the spring when the ice is breaking up, and is due almost exclusively to ice formed on the shore rather than in part by floe ice which comes down from the north after June.

In Tooktoosner Bay, Mr. Hind saw, "in a secluded and protected hollow, well-marked and deeply cut grooves. They occupied a shallow and cup-shaped basin, but all surrounding surfaces were smoothly polished, pan-ice having removed every trace of groove or striæ." Professor Hind concludes that no ice-foot is formed on the Labrador coast or in Greenland, but we should be disposed to question the validity of this conclusion, as we are inclined to ascribe the wearing and polishing of the rocks rather to ice formed on the coast than to foreign ice floating past the shore in summer. Professor Hind's conclusion we present in the author's own language: —

"It has been shown by Dr. Petermann and others that the difference between the coastal climate of Greenland and the Labrador is very great. The southwestern coast of Greenland is much milder than that of the Labrador in the same parallels.[2] A surface sheet of warm water, floating from south to north, is determined on to the coast of Western Greenland by the rotation of the earth. A cold arctic current laden with ice from Davis and Hudson straits flows from north to south and is determined on to the Labrador coast by the rotation of the earth. Hence the sea on the Labrador coast is cooled sometimes in November and early in December to 29°, and even 28°, and the lolly of the sealers, or ice spiculæ, or anchor ice, forms rapidly during the first cold snap in November, along the entire coast line; and before Christmas, all the coastal waters within the zone of islands are frozen in one solid sheet, so that no ice-foot is formed on the Labrador like the ice-foot on the Greenland shores. In brief, it may be said that the stupendous work of

[1] Glacial Phenomena of Labrador and Maine. Memoir of the Boston Society of Natural History, vol. i., 1867, pp. 225, 228. By A. S. Packard, Jr.

[2] Vide a paper entitled Further Enquiries on Oceanic Circulation, by Dr. W. B. Carpenter, F. R. S., Proceedings of the Royal Geological Society, August, 1874.

ice on the Labrador, apart from glacial sculpturing, appears to be almost altogether due to the periodical action of pan-ice deriving its power and constant opportunities from the arctic current, which presses continually on the Labrador coast."

New Fossil Fishes from Wyoming. — At a recent meeting of the American Philosophical Society, Professor Cope announced the discovery of a new locality of the Green River shales, containing fishes, insects, and plants in a good state of preservation. Owing to the rather soft nature of the matrix the characters of the fishes could be worked out with much nicety. A collection which he had recently received includes sixteen species of fishes, mostly new. Their names are as follows: —

? *Chromididæ: Priscacara serrata* Cope; *P. cypha* Cope; *P. liops* Cope.

Percidæ: Mioplosus abbreviatus Cope; *M. labracoides* Cope; *M. Beanii* Cope; *M. longus* Cope.

Asineopidæ: Asineops pauciradiatus Cope.

? *Aphredodiridæ: Erismatopterus Endlichii* Cope; *Amphiplaga brachyptera* Cope.

Clupeidæ: Diplomystus dentatus Cope; *D. analis* Cope; *D. pectorosus* Cope; *D. humilis* Leidy; *D. altus* Leidy.

Osteoglossidæ: Dapedoglossus testis Cope: *D. encaustus* Cope.

Of the above genera all but two are new to science, and all of the species but three are likewise new. From the present collection something like a general view of the ichthyological fauna can be obtained, since the predominant types are probably represented in it. *Priscacara* is a Pharyngognath allied to the *Chromididæ* and *Pomacentridæ*, most nearly to the former; and *Dapedoglossus* is not far removed from *Arapæma* and *Osteoglossum*. The facies of the fauna is of a mixed character, both fresh-water and marine types being present. The largest species is the *Osteoglossum encaustum;* the second in size is the *Diplomystus dentatus*, which exceeds the moss-bunker (*Brevurtia menhaden*).

The species and genera are in process of publication in the Bulletin of the U. S. Geological Survey of the Territories.

GEOGRAPHY AND EXPLORATION.

Rise of Great Salt Lake. — While I was spending a few days in June last at Salt Lake, my attention was called to the evident rise in the Great Salt Lake, which had taken place since my last visit to the lake, in August, 1875. The point where I noticed the fact of a rise was at Farmington, Utah, where from overflowed salt vats that were above water in 1875, and from the wearing away of the shore, I roughly judged that the lake had risen at least twelve inches. Mr. W. V. Haight, a farmer, who owns the land at the point visited, confirmed my impressions. At Lake Point, twenty miles east of Salt Lake City, the captain of the steamer General Garfield informed me that

from marks made by himself, on the piles of the wharf, the lake is fifteen inches higher than in July, 1875. It is to be hoped that the U. S. geologists will measure the oscillations of the lake.

Geographical News. — The *Geographical Magazine* for June contains a map of the seat of war in Asia, which is intended to assist its readers in following the military operations now being carried on in Asia. The editor observes that it possesses but few claims to accuracy, for of the countries delineated only a small portion has been made known to us through the surveys of Russian officers and of other Europeans, some of them in the service of Turkey.

Corea having entered into a treaty with Japan, there are prospects that this last of exclusive nations in the far East will have intercourse with other countries. A general account of Corea is given in the *Geographical Magazine.* A new map of Japan has been compiled by R. H. Brunton, formerly engineer-in-chief of the Japanese Light-House Department. It is said to be the only map of Japan which can be consulted with confidence. It is published by Trübner & Co., London. The Darien Exploring Expedition, under command of M. Lucien N. B. Wyse, returned to Panama early in April. M. Wyse has expressed his conviction, based on the results of these surveys, that the inter-oceanic canal will soon be made through Columbia. The proposed canal will have a length of 143 miles, including 46 miles of the Atrato and 43 of the Tuyra, which can be rendered navigable at small expense. At the confluence of Tuyra and Pucro the elevation above the sea is 92 feet, and it appears from a reconnaissance that the height of the water parting at the head of the Tihule does not exceed 230 feet. The late Dr. Maack, who was attached to the American Expedition as geologist, ascertained that the two oceans formerly communicated near this spot. The fossils discovered belonged to species still existing in the two oceans, The engineers would, therefore, only have to break through this barrier, which has been formed by an upheaval of the tertiary strata.

At the meeting of the Berlin Geographical Society, held May 12th, Baron Richthofen read a paper on the roads followed by the silk trade, according to Ptolemy and the Chinese authorities. It was announced at this meeting that Dr. Nachtigal proposed to start for Western Africa next year. In the mean time, it is proposed to dispatch a pioneer explorer to follow in the footsteps of Pogge and Mohr.

MICROSCOPY.[1]

Another Mechanical Finger. — Mr. Hanks, of San Francisco, Cal., at a recent meeting of the San Francisco Microscopical Society described a device used by him for picking up objects under the microscope, which answers nearly all the purposes of the most elaborate mechanical finger, and at the same time requires no extra apparatus. For the

[1] Conducted by Dr. R. H. Ward, Troy, N. Y.

purpose of lifting the object slide, when required, off the stage, the glass parabola is mounted in the substage in such a position that it can be raised by the substage rack until its upper surface is just above the level of the stage. The stand is arranged vertically, and a hair is placed in the stage forceps. For small objects a human hair is sufficient, but for larger ones a bristle is required, and it may even need to be slightly moistened when used, the object adhering while it is wet and falling off readily as it dries. If the hair is not easily held by the forceps, one end of it may be cemented between two small pieces of thick paper which are easily held. The slide containing the rough material is laid on the stage and the desired object selected and accurately centred; it is now, by the rack or sliding movement of the substage, lifted off the stage so as to be no longer affected by the stage movements. The end of the hair is next arranged just above the level of the object and centred exactly over it by means of the stage movements. Having got the end of the hair in the centre of the field, and having placed the object, dimly seen out of focus, below it, a slight elevation of the substage, which is still supporting the slide, will bring the object in contact with the hair and leave it there when the slide is lowered again. A fresh slide can then be substituted and brought up to the object on the hair, the exact position where it shall touch being secured by the stage movements, if the substage has no centring adjustments. Where the substage has rotating and centring movements of its own the performance is most complete and accurate.

It will be noticed that the principle of this method is the same as that of Dr. G. C. Morris,[1] the novelty consisting in the excellent suggestion of carrying the hair on the stage forceps instead of on a special arm clamped to the stage.

New Physician's Microscope. — For convenience of those who prefer a stand of the compact, Continental model, the Bausch & Lomb Optical Company, of Rochester, have designed a new form of instrument which they call the physician's microscope. In this stand Mr. Gundlach has reproduced the Continental model so well worked out by him while in Europe, with several of the novel features of the Rochester styles, such as his new fine adjustment, the hard-rubber stage and mountings, and the new students' series of objectives.

Tin Cells. — Prof. George F. Markoe, of 61 Warren Street, Boston, Mass., has had a set of dies prepared with which he is now able to produce tin cells of various sizes and excellent quality. Microscopists can obtain these serviceable cells from him, by mail or otherwise, at a reasonable cost.

Exchanges. — Diatoms from coörongite, from South Australia, for good mounted objects. Address Galloway C. Morris, East Tulpehocken Street, Germantown, Philadelphia.

Shell sand from the Bermuda Islands, for any really valuable mate-

[1] See Arranging Diatoms, in the Naturalist for August, 1876, p. 502.

rial; or selected shells from the same, for mountings of special interest. Address C. C. Merriman, Rochester, N. Y.

Insects' eggs; also American podura. Whole insects or scales. Address George W. Frees, Friendship, N. Y.

Algæ from California and Japan, on which are fine circular diatoms. Address W. C. J. Hall, Jamestown, N. Y.

Scales of hunting spider, *Salticus senicus*. Address William Readio, Garnerville, Rockland County, N. Y.

Oölitic sand from Salt Lake. Address F. H. Atwood, 160 Lasalle Street, Chicago, Ill.

Lupulin crystals in extract of hops. Address Richard Allen, 146 North Fourth Street, Troy, N. Y.

Diatoms from Keene, N. H. Address Edwin S. Gregory, Youngstown, Ohio.

Diatoms from Lake Superior; dredgings eight feet deep near the head of Portage Lake. Address Dr. T. U. Flanner, Springfield, Mo.

A variety of mounted objects for exchange. Address offers to Frederick A. Eddy, 89 State Street, Bangor, Me.

SCIENTIFIC NEWS.

— Dr. Joseph D. Hooker, keeper of the Kew Botanical Gardens, England, and Professor Asa Gray, of Cambridge, are both temporarily attached to the U. S. Geological and Geographical Survey of the Territories, Dr. F. V. Hayden, U. S. Geologist, in charge. In company with Dr. Hayden they have visited various portions of Colorado, making the ascent of Gray's Peak, and exploring the interesting flora of the mountains and parks, as well as that of the foot-hills and adjacent plains. Previous to August 1st, these eminent botanists had collected nearly four hundred species of rare plants, being thus enabled to study critically in their native habitats the species they had during past years described from dried specimens brought in by expeditions. Both of these gentlemen will prepare reports on the botany of the West for the Eleventh Annual Report of Hayden's Survey. A preliminary report by Dr. Hooker is already well advanced. After a sojourn of several weeks in Colorado and Utah, they left Salt Lake City, August 11th, for the Pacific Coast.

— The Summer School of Biology at the Peabody Academy of Science, Salem, Mass., opened July 7th with twenty-one laboratory students, while a few others attend the daily lectures. This is a larger number than were present last year. Lectures have been given by Mr. J. H. Emerton, Rev. E. C. Bolles, Mr. John Robinson, Professor J. Ramsay Wright, of Toronto, Rev. T. C. Hervey, Mr. C. S. Minot, and Dr. Packard. Material for dissection from Woods Holl, Mass., has been contributed by Professor Baird, U. S. Commissioner of Fish and Fisheries.

— It should be stated that the review of Ganin's Metamorphoses of Insects in the July NATURALIST was contributed by Baron C. R. Osten-Sacken. As the original was in the Russian language, no one else in this country was probably competent to perform the task.

— Captain Howgate, U. S. N., has obtained from the friends of his Polar colonization plan the means of chartering the schooner Florence, which sailed July 25th from New London for the arctic regions, for the purpose of making a preliminary exploration of Northumberland Inlet, with the view of establishing a post there next year.

— The Académie Royal Danoise des Sciences et des Lettres proposes among its prize questions for the year 1877, the following: The gold medal of the Academy is offered in competition for memoirs, based on original research, respecting the external and internal structure met with in (*a*) individuals which turn to the left, as compared with that of those which turn to the right, belonging to the same species, as, for example, among Vertebrates, the flounder and other flat fishes, and, among Gasteropods, the genus *Verruca;* (*b*) the same in species turning to the left, as compared with others turning to the right, which belong to the same genus, as, for example, the genera *Fusus*, *Vertigo*, *Turritella*, *Chama*, etc.; (*c*) the same in genera turning to the left, as compared with genera turning to the right, belonging to the same family, as, for example, the turbots and the true *Pleuronectidæ*, and the genera *Clausilia* and *Pupa*, *Lanistes* and *Ampullaria*, *Physa* and *Planorbis*, etc. The Thott prize of four hundred crowns is offered for memoirs on the anatomy, life-history, and development of the species of *Ligula*, with special reference to their relationship to the Platyhelminths. Memoirs offered in competition for these prizes should be accompanied by figures and preparations which may serve as a guaranty for the correctness of the anatomical results obtained.

— There will be room for one or two special students in zoölogy at the Peabody Academy in October. Address A. S. Packard, Jr., Director Peabody Academy of Science, Salem.

— The following is taken from the *Philadelphia Ledger Supplement*, May 5, 1877: —

MR. EDITOR, — If you will, let me in a plain, simple way revive the memory of your oldest readers, feeling that some of them may visit the grave of Professor S. C. Rafinesque, Ronaldson's Ground, Ninth and Bainbridge streets. Rafinesque was born in France, of parents in high position. He was an orphan, yet his means gave him a classical education. He visited the four quarters of the globe. In his first trip to America he was shipwrecked on Nova Scotia, losing a part of his fortune. Having spent one or two years in the United States he returned to Europe. A few years later he returned to Philadelphia. Rafinesque was a devoted naturalist. To conchology he gave much of his time and labor, collecting a great variety of shells, publishing a volume illus-

trated with engravings. He also published a work on grape-vines, giving the mode of making wine. After suffering many vicissitudes and losses in money, and having accumulated scientific treasures, he gave his entire attention to the science of botany. He traversed this continent from Nova Scotia to Mexico, from the Atlantic coast to the Rocky Mountains. In every State and Territory he pursued his way on foot and alone in his devotion, over valleys and mountains, often depending upon the kindness of Indian tribes. After several years of constant labor he returned to Philadelphia. He was a bachelor, consequently peculiar in his habits. He selected a garret for his labors, and abode in Race Street between Third and Fourth. In this secluded place, surrounded with his herbarium, his sketches, and pencil drawings, with hard cot and pillow, often with a bare loaf of bread, he performed his last work, The Family Flora and Medical Botany of the United States. This work on the science of botany was more extended and correct than anything before it. It was printed and published in 1828, by the late Samuel C. Atkinson, who established the *Saturday Evening Post*, Carter's Alley.

Without kindred, and with but one reliable friend, the late Dr. Mease, of Philadelphia, Rafinesque died in the year 1840. After his remains had been cared for by Dr. Mease, the body was stealthily removed (probably by creditors), and locked in an adjoining room of the house where he died. In presence of Dr. Mease and Mr. Bringhurst, undertaker, Eleventh Street, near Arch, the door was forced open, and the body was let down by ropes into the back yard and conveyed to its last place of rest.

Some sixteen years ago I called on Mr. Bringhurst, who assured me of these facts relating to the burial. I visited the burial ground. The sexton referred to his records and took me to the grave of Rafinesque. A small painted head-board had the initials S. C. R.

Rafinesque published several volumes and essays in the French and English languages. Two years since I forwarded his last work to the National Library of France, and received acknowledgment through the French consul, Philadelphia. — H. H.

— The Central Pacific Railroad Company are doing a good work in tree planting, having already purchased forty thousand Eucalyptus trees to plant along the line of their road. This enterprising company intend planting certain species of the Eucalypti on each side of their right of way through some five hundred miles of the valleys of California; it is estimated that eight hundred thousand trees will be required for this purpose. — R. E. C. S.

— Seal catching for oil is being pursued on the Point Reyes side of Tomales Bay, California, the average yield being about five gallons to the seal, worth fifty cents per gallon.

SCIENTIFIC SERIALS.[1]

THE GEOGRAPHICAL MAGAZINE. — July. The Arctic Expedition, xvi. Work of the Auxiliary Sledge Parties (with a Chart of Archer Fiord, and Plan of Petermann Fiord). The Himalayan System, by F. W. Saunders (with Map of the Himalaya and Tibet, — a View of the Mountain System bounded by the Plains of India, Gobi, China, and the Caspian). The India-Rubber Trees in Brazil, by R. Cross.

JOURNAL OF THE ACADEMY OF NATURAL SCIENCES. — Vol. viii., Part 2. 1876. On the Batrachia and Reptilia of Costa Rica, by E. D. Cope. On the Batrachia and Reptilia collected by Dr. J. M. Brandsford during the Nicaraguan Canal Survey of 1874, by E. D. Cope. Report on the Reptiles brought by Prof. J. Orton from the Middle and Upper Amazon, and Western Peru, by E. D. Cope. Note on the Ichthyology of Lake Titicaca, by E. D. Cope. A Descriptive Catalogue of the Scalidæ of the West India Islands, by O. A. L. Mörch.

CANADIAN NATURALIST, viii. 5. — Notes on some Geological Features of the Northeastern Coast of Labrador, by H. Y. Hind. New Facts relating to Eozoön Canadense, by J. W. Dawson.

ANNALES DES SCIENCES NATURELLES, ZOOLOGIE. — June 15. Études monographique sur les Assiminées européennes, par M. Paladilhe. Études sur les Bryozoaires entoproctes, par M. Salensky. Mémoire sur l'Appareil musical de la Cigale, par G. Carlet.

MONTHLY MICROSCOPICAL JOURNAL. — July. Thermo-Dynamic Origin of the Brownian Motions, by J. Delsaulx. An Explanation of the "Brownian" Movement, by W. N. Hartley. An Essay on the Classification of the Diatomaceæ, by P. Petit. The Histology of the Island of Reil, by H. C. Major. The Microscopes at the American Exhibition, by J. G. Hunt. Opaque Objects with High Powers, by G. W. Moorehouse. A Simple Form of Mechanical Finger for the Microscope, by G. Hawks.

AMERICAN JOURNAL OF SCIENCE AND ARTS. — August. Notes on the Internal and External Structure of Paleozoic Crinoids, by C. Wachsmuth. Relations of the Geology of Vermont to that of Berkshire, by J. D. Dana.

BULLETIN OF THE NUTTALL ORNITHOLOGICAL CLUB. — July. The Birds of Guadalupe Island discussed with reference to the present Genesis of Species, by Robert Ridgway.

THE POPULAR SCIENCE REVIEW, London. — July. Studies amongst Amœbæ, by P. M. Duncan. Notes on the Geographical Distribution of Animals, by W. F. Kirby.

ERRATUM. — Page 350, in the division under "North America. — East Coast," for *Metanhock* read *Metauhock*, and for *Suckanhock* read *Suckauhock*; these errors occur thrice.

[1] The articles enumerated under this head will be for the most part selected.